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VOL. CL.—No. 3907] LONDON: FRIDAY EVENING, NOVEMBER 28, 1930 [PRICE {WITH SUPPLEMENT} ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department, Belvedere-road, Lambeth, London, S.E. 1, invites TENDERS for :—

460 STEEL SLIDE BARS for LOCOMOTIVES.

Tenders due 17th December, 1930.

Forms of Tender available from the above at a fee of 5s., which will not be returned. 6143

UNIVERSITY OF DURHAM.

Armstrong College, Newcastle-upon-Tyne.

LECTURESHIP IN CIVIL ENGINEERING.

The Council of Armstrong College invites APPLICATIONS for a LECTURESHIP in CIVIL ENGINEERING. Salary, £300 to £350, according to qualifications. Candidates must have had practical experience and have a good knowledge of Surveying. Preference will be given to candidates between the ages of 25 and 35. Duties to commence as soon as possible. Ten copies of applications and of not more than three testimonials should be lodged, not later than Monday, 8th December, 1930, with the undersigned, from whom further particulars may be obtained.

J. Y. T. GREIG,
Registrar.

6128 Armstrong College.

City of Oxford Education Committee.

CITY TECHNICAL SCHOOL AND MUNICIPAL SECONDARY SCHOOL.

WANTED for January next, a GRADUATE in ENGINEERING, to Take Charge of the Engineering Department in the Technical School and Assist with Middle Form Mathematics in the Municipal Secondary School. Burnham Scale.

Applications, supported by testimonials, should reach the Principal not later than 5th December.

A. C. CAMERON,
Secretary for Education.

Education Office,
City Chambers, Oxford,
26th December, 1930. 6148

Robert Gordon's Colleges, Aberdeen.

MECHANICAL ENGINEERING DEPARTMENT.

APPLICATIONS are INVITED for the POST of LECTURER in the above-named Department. Candidates should be Graduates in Engineering with works and teaching experience or equivalent qualifications. The appointment will date from 5th January or as soon thereafter as may be arranged.

Salary £300, rising by annual increments of £15 to £360.

The College co-operates with the University of Aberdeen in providing courses leading to the Pass and Honours Degrees of B.Sc. in Engineering.

Form of application and further particulars may be obtained from the undersigned, to whom 16 copies of application, together with 16 copies of at least three testimonials, should be addressed not later than 6th December, 1930.

JAMES McKENZIE,
Secretary and Registrar.

Robert Gordon's Colleges, Aberdeen,
24th November, 1930. 6132

Newcastle-upon-Tyne Electric Supply Company, Limited.

TENDERS are INVITED for the SUPPLY, DELIVERY and ERECTION, at the Company's Power Station, Dunston-on-Tyne, of the following PLANT :—

PIPING EQUIPMENT for Power Station, including High-pressure Steam Piping, Boiler Feed Water Piping, all Water Service Piping and Auxiliaries and Fittings.

Copies of the form of Tender and specification (No. N.260) may be obtained on and after the 3rd December, 1930, from the Company on the payment of a deposit of Two Guineas per copy, but not more than three copies will be supplied to any one applicant.

After a decision has been made with regard to the Tenders received deposits will be returned to those who have submitted bona fide Tenders and have not withdrawn them.

Tenders, in duplicate, on the forms supplied, contained in envelopes endorsed "Tender for Specification No. N.260," must reach the Secretary of the Company at Carliol House, Newcastle-upon-Tyne, not later than Twelve o'clock Noon on January 14th, 1931.

The Company does not bind itself to accept the lowest or any Tender.

C. SKIPSEY,
Joint Secretary.

Carliol House, Newcastle-upon-Tyne,
25th November, 1930. 6135

South Indian Railway Company, Limited.

The Directors are prepared to receive TENDERS for the SUPPLY of—

1. CARRIAGE UNDERFRAMES.
2. ROLLED STEEL DISC WHEELS and AXLES.
3. FIREBRICKS.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked, "Tender for Carriage Underframes," or as the case may be, with the name of the firm tendering, must be left with the undersigned not later than Twelve Noon on Friday, the 19th December, 1930, in respect of Specification No. 1, and not later than Twelve Noon on Friday, the 12th December, 1930, in respect of Specifications Nos. 2 and 3.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of Specification No. 1 and of 10s. for each copy of Specification No. 2, and of 2s. 6d. for each copy of Specification No. 3.

Copies of the drawings may be obtained at the offices of the Company's Consulting Engineers, Messrs. Robert White and Partners, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France,
Westminster, S.W. 1,
26th November, 1930. 6153

The Engineer

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PUBLIC NOTICES

County of London.

The London County Council invites TENDERS for the PURCHASE, DISMANTLING and REMOVAL of TWELVE WATER-TUBE BOILERS, SIX ECONOMISERS and FOUR FEED PUMPS, &c., at present installed in the Tramways Power Station at East Greenwich.

Particulars and forms of Tender may be obtained from the General Manager of Tramways, 23, Belvedere-road, S.E. 1, who will also give facilities for the plant to be inspected between the hours of 9 a.m. and 5 p.m. on any weekday except Saturday.

Tenders must be delivered to the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1, not later than 4 p.m. on Monday, 15th December, 1930.

The Council does not bind itself to accept the highest or any Tender.

MONTAGU H. COX,
6140 Clerk of the London County Council.

Stockport Corporation Waterworks.

GOYT VALLEY SUPPLY.—CAST IRON PIPES AND SPECIAL CASTINGS.

TENDERS are INVITED for the SUPPLY of about 2500 TONS of CAST IRON PIPES and SPECIAL CASTINGS, chiefly 30in. diameter.

The drawing may be seen and specification, schedule, with form of Tender obtained on application to Messrs. G. H. Hill and Sons (Manchester), Civil Engineers, 40, Kennedy-street, Manchester, upon receipt of a cheque for One Guinea, which will be returned to the applicant provided that he shall have sent in a bona fide Tender, shall not have withdrawn same, and shall have returned the documents and drawing lent to him.

A limited number of copies of the drawing are available, and will be lent to persons tendering in priority of application on receipt of the sum of Half-a-Guinea, which sum will not be returned.

Sealed Tenders, endorsed "Tender for Cast Iron Pipes: Goyt Supply," and addressed to "The Chairman of the Waterworks Committee," must be delivered at the Waterworks Offices, Town Hall, Stockport, not later than December 16th, 1930.

The Committee do not bind themselves to accept the lowest or any Tender.

ROBERT HYDE,
Town Clerk.

Town Hall, Stockport,
November 24th, 1930. 6133

PUBLIC NOTICES

The Maldens and Coombe Urban District Council.

The above Council is prepared to receive TENDERS for the PURCHASE of MACHINERY as follows :—

One 50 horse-power Horizontal Tangye Gas Engine ;
One 12in. Tangye Centrifugal Pump ;
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The above can be seen working by appointment.

All plant is to be removed by the purchaser.

JAMES WM. JOHNSON,
Clerk of the Council.

Council Offices, New Malden, Surrey. 6134

Rhyl Urban District Council.

RHYL SEWERAGE.

APPOINTMENT OF CLERK OF WORKS.

The Council REQUIRE the SERVICES of an ENGINEER, to act as Clerk of Works, in connection with the Construction of about 5 Miles of 30in. diameter Sea Outfall Sewer, 36in. to 9in. diameter Concrete Tube or Stoneware Pipe Sewers and Rising Mains, Reinforced Concrete Pump Well, Pumping Station and Incidental Works in connection therewith.

Applicants must be fully qualified by actual experience in similar work and must be competent in the use of the level and theodolite and able to set out, test and measure up the works and check accounts.

The salary will be at the rate of £375 per annum, and, subject to satisfactory service, the appointment will be for the period of the construction of the works, which, it is estimated, will occupy at least 18 months.

The person appointed will be required to act under the instructions of the Council's Consulting Engineer, Mr. Robert Green, M. Inst. C.E., 37, Bennetts-hill, Birmingham, from whom applicants can obtain a copy of the prescribed form of application, which must be filled in and delivered to me not later than the 22nd December, 1930.

T. AMOS JONES,
Clerk to the Council.

Council Offices, Rhyl,
27th November, 1930. 6151

PUBLIC NOTICES

Great Southern Railways.

290 TONS STEELWORK FOR BRIDGES.

The Directors are prepared to receive TENDERS for the SUPPLY and DELIVERY of approximately 290 TONS of STEELWORK for BRIDGES, consisting chiefly of Plate Girders, Pressed Troughing, Broad Flange Beams and British Standard Beams.

Specifications and drawings can be obtained on payment of £1 1s. (which is not returnable) from A. W. Bretland, Esq., Chief Engineer, Westland Row Station, Dublin, C. 5.

The Directors do not bind themselves to accept the lowest or any Tender.

Tenders, in envelopes endorsed "Tender for Steelwork for Bridges," must reach the undersigned not later than 5 p.m. on Tuesday, the 23rd December, 1930.

H. S. COE,
Secretary.

Kingsbridge Station, Dublin, W. 6,
November, 1930. 6147

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, ASSISTANT ENGINEER for Sugar Factory in British Guiana, age about 25, technical and practical training, drawing-office experience essential ; higher National Certificate or equivalent.—Reply, giving particulars qualifications, expected salary, Z.S. 539, care Deacon's, Fenchurch-avenue, E.C. 3. 6145 A

WANTED, ENGINEER to Act as COMPRESSED AIR INSPECTOR for a group of Collieries in South Wales.

Experience of underground conditions essential, also of Testing Apparatus and in the use of Compressed Air Apparatus in use underground.

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For continuation of For Sale Advertisements see page 4.

A Seven-Day Journal

Sir George Humphreys.

On Monday of next week, December 1st, Sir George Humphreys retires from his position as chief engineer and administrator of housing and development schemes to the London County Council. He has occupied that post since 1913, when he succeeded the late Sir Maurice FitzMaurice. He entered the Council's service in 1902 as manager of works, and in 1912 was appointed deputy chief engineer. At the Council meeting last Tuesday the General Purposes Committee called attention to Sir George's retirement and submitted a report recommending the retention of his services for a time in connection with certain uncompleted works. One such work is the enlargement of the tramway subway beneath Kingsway, which is expected to be reopened towards the end of December. In connection with the development of the Council's housing estates, the Committee recommended that Sir George's services should be retained until December 31st, 1931, for the purpose of advising his successor, Mr. T. Peirson Frank, regarding the past history of the contracts concerned in the work. The Committee further recommended that Sir George should remain engineer responsible for the work of rebuilding Lambeth Bridge until it was finished. Concerning the reconditioning and widening of Waterloo Bridge, the Committee recommend that as from the date of Sir George's retirement the Council's chief engineer should cease to be associated with the work, and that Sir Frederick Palmer should act alone as engineer responsible for it. The Council's chief engineer was also associated with Sir Frederick Palmer as responsible engineer and Sir Basil Mott as consulting engineer in connection with the Charing Cross Bridge scheme. The Committee, on Tuesday, made no recommendation as to the continuance or severance of this association, but intimated that the Improvements Committee proposed to consider what arrangements should be made for the conduct of the engineering side of any new Charing Cross Bridge scheme which the Council might adopt. The recommendations made by the General Purposes Committee were unanimously adopted by the Council, which also passed a resolution in appreciation of Sir George Humphreys' work.

The Fulham Power Station.

At a meeting of the London County Council, held on Tuesday last, it was decided to oppose the application by the Fulham Borough Council to the Electricity Commissioners for leave to extend the generating station in Townmead-road, Fulham. The Chairman of the Parliamentary Committee, Dame Beatrix Lyall, said that experiments had been made in connection with the elimination of sulphur fumes. The views of the Government Chemist on the report of the advisers to the London Power Company, which was erecting a station at Battersea, were not received before the agenda was drawn up, and in view of the time limit for objections, it was essential that the Committee should be armed with powers to safeguard the Council's position. The proposed extension would be in effect a new power station, and it would be built by arrangement with the Central Electricity Board and as part of the South-East England electricity scheme. Its ultimate capacity of about 318,000 kW would be approximately that of the Battersea power station of the London Power Company, and the first instalment of the new station would be about one-third of that capacity.

Posts for Students.

In this time of industrial depression it would be only reasonable to expect that students, on completing their college courses, would find great difficulty in obtaining suitable employment. That expectation is pleasantly falsified by the annual report, just issued, of the Royal Technical College, Glasgow. The Governors state that the demand for thoroughly trained and able young men in most of the sections of engineering has, apparently, had little relation to the falling off in production. It is, they add, perhaps because of this falling off that employers have sought the services of students to an extent which the college could not meet. In metallurgy, they state, there are still insufficient candidates to meet the demand for fully qualified men, and it is believed that every graduate and associate of the college in that subject has been placed in a lucrative position. In civil engineering there is a considerable demand for students who have completed their course of study, and at the end of last session three or four times as many graduates as were available could have been placed in remunerative employment. In mechanical engineering the demand for college graduates, it is noted, is now less largely confined to men who are to be engaged in design, but an increasing number of requests has been received for nominations of students and past students to positions as workshop managers and assistant managers. There is also observable a growing demand to secure the services of qualified engineers for the selling side of the industry. In electrical engineering the demand for graduates has far exceeded the supply, and it is now no uncommon thing for all the day students in the Department about to complete their course to have received appointments before the end of the winter session. In order that these facts as to the employment of the students may be judged properly, it is necessary to add that the Royal Technical College is a large institution, the individual students last session numbering nearly four thousand. There were 301 students in the Department of Metallurgy, 683 studying civil engineering, and 1470 and 743 respectively in the Mechanical and Electrical Engineering Departments. It would be interesting to know the exact experience of other colleges as regards the demand for the services of the men which they train.

Inst. Mechanical Engineers Midland Branch.

On Tuesday evening the annual dinner of the Midland Branch of the Institution of Mechanical Engineers was held in the Queen's Hotel, Birmingham, when the attendance reached a new record, over 150 ladies and gentlemen being present. The chair was taken by Mr. Frederick Samuelson, Chairman of the Branch, and the President of the Institution was amongst the guests. The evening was a very pleasant one, the speeches, none of which were over long or over serious, being interspersed with well-selected songs well sung. The toast of the "City and Industries of Birmingham" was brightly proposed by Mr. Frank Somers, and an able response was made by the City Surveyor, Mr. H. H. Humphries, who, at the last moment, took the place of the Lord Mayor, who was absent owing to illness. Mr. Humphries alluded to the time, not very many years distant, when the artificial boundaries which hampered developments and increased expenditure would be swept away, and Birmingham, with all the surrounding districts, would form a single municipal unit. The toast of the "Guests and Kindred Societies" was proposed by Mr. G. N. Guest, and was acknowledged by the Master of Sempill and Mr. Frank Forrest, the Chief Electrical Engineer of the City. The Master of Sempill, in a very effective speech, spoke of the future of aviation, which, he claimed, was making rapid economic strides, as shown by the reduction of subsidies, and he urged Birmingham to show more keenness in the subject and to press forward with the development of its aerodrome. He paid a tribute to Dr. Lanchester, who had laid the basis of scientific aero-dynamics and whose work was only now coming into its own in this country. The last toast, that of "The Institution," was given by the Chairman. He recalled that the Institution was founded in 1847 on the very site upon which the dinner was being held. It began with 107 members. Ten years later it had ten times that number, and it now had ten times again—just over 10,700 members. Mr. Samuelson described also some of his early memories of Swedish engineering, amongst which a mechanical transmission three miles long by wooden rods moving to and fro three times a minute, made a great impression on the audience. The toast was acknowledged by the President, who, reminding engineers of the greatness of British invention, urged them to give the first preference to the home inventor and not to wait till British inventions returned with foreign names and the right to work them had to be purchased.

A Scottish Steel Works Fusion.

Early in December meetings are to take place in order to sanction a provisional agreement which has been entered into between James Dunlop and Co. and David Colville and Sons for a fusion of interests under the style of a new company, Colvilles, Ltd. The share capital of the company is to be £4,500,000, of which the sum of £4,050,000 will be allotted as fully paid to David Colville and Sons and £450,000 to James Dunlop and Co. The new company will acquire as from January 1st, 1931, from James Dunlop and Co., the Clyde Ironworks at Tollcross, the Calderbank Steel Works at Airdrie, the Clyde coalfield and other land, along with the Clyde and Calderbank collieries. From David Colville and Sons the Dalzell Steel and Iron Works at Motherwell, the Clydebridge Steel Works at Cambuslang and the Glengarnock Iron and Steel Works at Glengarnock are to be taken over by the new company, which will also acquire as floating stocks and other working capital the sum of £585,000 from David Colville and Sons and £65,000 from James Dunlop and Co. It is proposed to continue the existence of the Dunlop Company as a concern holding its allotment of shares in the new company and operating the Cardowan Colliery, which has now reached the producing stage, and which will cost, when finally completed, not less than about £480,000. The Calderbank Steel Works, which are to be merged into Colvilles, Ltd., were closed down on Saturday last.

More Shipyards to be Dismantled.

At the end of last week an announcement was made by National Shipbuilders Security, Ltd., to the effect that it had purchased, for dismantling, two more Scottish shipyards, and one at Lowestoft. Negotiations are also proceeding with some shipyards on the North-East Coast, but so far no final decision has been reached with regard to them. The three yards in question comprise those of Napier and Miller, Ltd., at Old Kilpatrick, near Glasgow; the South Yard of the Ardrossan Dockyard Company, Ltd., at Ardrossan, Ayrshire, and the yard and engineering works of John Chambers, Ltd., of Lowestoft. The last-named yard has six berths, which can be used for vessels up to 250ft. in length. At Ardrossan the dockyard company will continue its shipbuilding and ship-repairing business at the North Yard, although, in the South Yard the five berths suited for building cargo ships up to 500ft. in length will be dismantled. The shipbuilding business of Napier and Miller has been in existence since 1898, when it was founded by Mr. Henry M. Napier, a grandson of the famous Robert Napier, and Mr. George M. Miller, who previously had charge of the shipyard of Charles Connel and Co., at Scotstoun. The company took over the existing establishment of Napier, Shanks and Bell at Yoker, and up to 1906 turned out some 66 vessels. As the site of the yard at Yoker was required for the construction of the new Rothesay Dock, a new site was acquired further down the river at Old Kilpatrick, from which the first ship, the "Irish Monarch," was launched in August, 1906. Between that time and 1928 over 18 steamers of the "Monarch" type were built by the firm. In all, a total of 130 ships were launched from the new yard. It is understood that no further negotiations are in progress in the Clyde area, the object of National Shipbuilders' Security, Ltd., being to secure an orderly and proportionate curtailment of capacity in all the different shipbuilding centres.

The Santander—Mediterranean Railway.

On Thursday of last week, November 20th, the Spanish Minister of Public Works officially declared open the section of the Santander–Mediterranean Railway between Trespaderne and Cidad. With the newly opened section the line from Calatayud to Cidad, extending over 220 miles, is now completed, and it only remains to construct a further 30-mile section to Santander, work on which has been delayed pending a Government decision. The company obtained the concession to build the railway in 1924, and the contract for construction was placed with the Anglo-Spanish Construction Company. The country through which the line passes is very heavy, but the work of construction has been carried out punctually, although often in the face of topographical difficulties. These difficulties, it is understood, have been further added to by changes in administration following political changes in the Government. The work was begun early in 1925, and by two years from that date the first section of the railway from Burgos to Cabezon de la Sierra was opened, the town of Soria being reached in January, 1929, while in October of the present year the new line was continued to Calatayud. The cost of the railway per kilometre, complete with permanent way and rolling stock, is stated to work out at approximately £14,000 at the present peseta rate.

British and French Shipbuilders.

Following a visit paid this year to Great Britain, a deputation of French shipbuilders has published a report in which it shows that British shipbuilders are building ships much more cheaply than French builders, in spite of the fact that they have to pay considerably higher wages. The delegates state that in the case of four cargo ships and two trawlers, the British tenders were from 19·5 to 24·6 per cent. lower than the French tenders for the same vessels. Since the date of these tenders the disparity has increased. At present the advantage in favour of this country would, it is stated, be as high as 30 to 33 per cent. Wages in the British shipbuilding industry, according to the report, are 40 per cent. higher than in the French industry. As our correspondent in Paris has already reported, the situation of the French shipbuilding industry and the continued placing of orders abroad by French shipowners is a subject of great anxiety to the French Government, which, so far, has not been able to propose any scheme for improving it which is acceptable both to the shipowners and the shipbuilders. The French delegation was primarily concerned with a study of British shipbuilding methods. It is particularly interesting to note that it did not everywhere find our methods above criticism. In one instance, in particular, the equipment was found to be rudimentary in the extreme, but in spite of that fact the yard concerned was well employed.

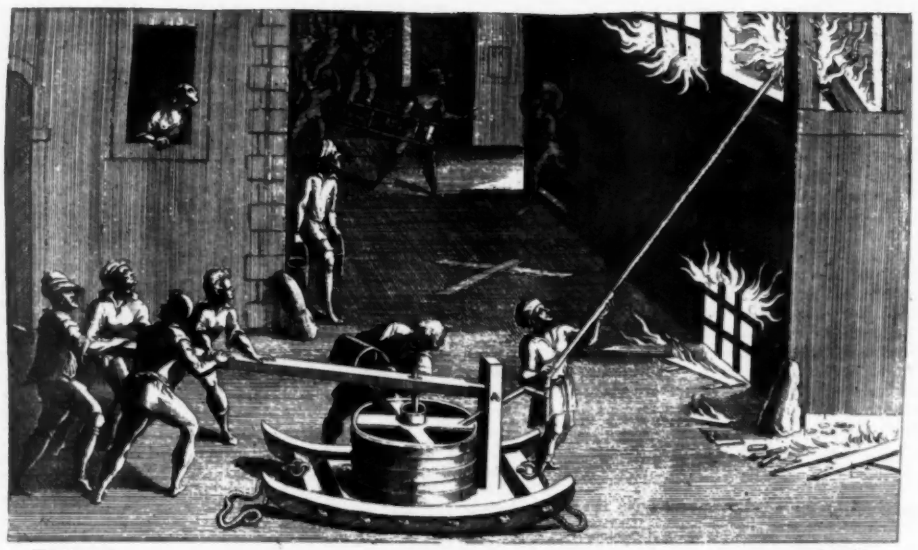
Oxygen and Acetylene.

Circular letters have been issued this week to the shareholders of the British Oxygen Company, Ltd., and Allen-Liversidge, Ltd., in which a proposal is made for the complete amalgamation of the two businesses. For many years the two companies have been working in close co-operation, so much so that a factory for the production of dissolved acetylene, the chief product of Allen-Liversidge, is usually to be found in the immediate vicinity of the oxygen works of the other company. The adjacent factories supply their products to a large extent to the same customers. The case for amalgamation is therefore claimed to be strong. The fusion will, if the shareholders give their consent, be brought about by the British Oxygen Company purchasing the whole of the issued shares of Allen-Liversidge.

Fire-extinguishing Engines in England, 1625—1725.*

By RHYS JENKINS.

THE main object of this paper is to draw attention to a patent granted by James I. in 1625 and the introduction into this country of the fire-extinguishing engine—that is to say, of a portable apparatus comprising a cylinder-and-piston pump adapted for continuous operation. Before this, apparatus in the form of a large squirt mounted on wheels, and having its piston worked by screw and nut mechanism, had been illustrated in the books of Besson[1] and the English writer Cyprian Lucar,[2] and there is some reason for thinking that such an apparatus was in use in London, for we find a German visitor stating that in 1584 he saw at the head of a Lord Mayor's procession a contrivance intended for putting out fires, from which water was squirted upon the crowd of people in the streets, in order to clear the way.[3]



FROM "LES RAISONS DES FORCES MOUVANTES" BY DE CAUS, 1615

The earliest description of a force pump fire engine in modern times is found in the "Theatrum Machinarum" of Heinrich Zeising (1612–14). His pump is very much like that of Hero, and it is possible that he may have known of Hero's pump, either from a printed book or from a manuscript, but in that case one wonders why he discarded the air vessel.

Following Zeising very closely we have Salomon de Caus, illustrating in his "Les Raisons des Forces Mouvantes" (1615) a fire engine that he had seen at Nuremberg. From the drawing it seems clear that this consisted of a single vertical cylinder, with a piston worked to and fro by a hand lever. This engine was no doubt made by the celebrated Nuremberg mechanician Hautsch; another engine by the same man, or perhaps by his son, is described by Caspar Schott in "Magia Universalis" (1657). In this, the cylinders were placed horizontally, and it seems likely that Hautsch made engines in a variety of forms, but there is little recorded as to the constructions he adopted. It appears from what Schott says that he objected to showing the internal construction of his engines.

Coming now to the patent. It was granted in 1625 to Roger Jones, but it seems, from the terms of the grant, that it was his brother John who, in his travels beyond the seas, had found out and discovered the new engine or instrument, with screws and other devices, made of copper and brass, for the casting of water with a spout of copper or brass. Roger, however, had assisted in perfecting the engine, and at his brother's request the patent was issued in his name.

In Fuller's "Worthies" (1662) we have an account of the introduction of the engine, which supplements the information given in the patent, and is of particular value, inasmuch as we may take it as a contemporary account—Fuller was born in 1608 and died in 1661. He tells us that "one Mr. Jones, a merchant living in Austin Fryers, fetched the first form thereof from Norimberge and obtained a patent from King James that none should be made without his approbation." This Mr. Jones, says Fuller, "dye'd in the great plague, *primo Caroli primi*" *i.e.*, between March, 1625, and March, 1626, and so very soon after the patent was granted.

According to the patent, the engine had been used lately at a fire in the dwelling-house of James Demetrius, a brewer in St. Katherine's, near the Tower. Fuller, on the other hand, states that at the time of Mr. Jones's death two engines were under construction, but neither of them finished. Possibly both statements are correct; the engine may have been used at the brewer's in an incomplete state, or in use there, defects may have developed or revealed themselves which took some time to rectify. The engines were made by one William Burroughs, from whom, no doubt, Fuller obtained some of his information; at any rate, he proceeds to say that since the death of Jones "William Burroughs, City Founder, now living in Lothbury, hath so completed this instrument that his additions amount to a new invention," and that he had made about three-score of the engines for City and country. Particular mention is made of an engine in the Church of St. James, Clerkenwell, and another at St. Bridget's. There is nothing to show the date on which Fuller's account was written; but it is safe to say that between 1625 and 1660 Burroughs had made sixty engines.

Another contemporary writer is John Bate, who brought out his book "The Mysteries of Nature and Art" in 1634. Here we find an account of what he calls "An engin to force water up to a high place; very useful for to quench fire amongst buildings." The apparatus is a vertical-cylinder force pump. The description and sketch are not very clear, but it seems that the piston was of some length, that at the centre of its upper end was fixed a screw, and in the centre of the lower end a nut. The screw worked in a nut fixed in a cross bar at the top of the cylinder, and the nut on a screw centrally fixed at the bottom of the cylinder. At the top of the piston was fixed a radial arm, and by moving this to and fro the piston was rocked on its axis and so, by the screw-and-nut mechanism, moved up and down. Bate tells us that this engine "will cast the water with mighty force up to any place you direct it," and his sketch shows the delivery pipe mounted on some sort of ball joint.

It seems fairly certain that we have here "the new engine or instrument with screws and other devices made of copper and brass" referred to in the patent. The construction is not one that we can consider likely to give good results in practice, and no doubt the maker soon had to cast about for a new form. Possibly the next construction tried was one that we find likewise in Bate. It is a form of bellows pump, consisting of two flanged brass bowls facing each other and connected by a collapsible leather tube—the tube is not described or shown, but it is clear that something of the sort must have been used. The upper bowl, inverted, is fixed to the frame of the apparatus, while to the flange of the lower bowl are secured two vertical rods which slide through holes in the frame and at their upper ends are united by a cross bar to which the inner end of the operating lever is jointed. An inlet valve is fitted at the bottom of the lower bowl, and a delivery valve at the top of the upper bowl. As will appear later, Bate had seen this apparatus at work. It will, he says, "with great violence cast the water on high."

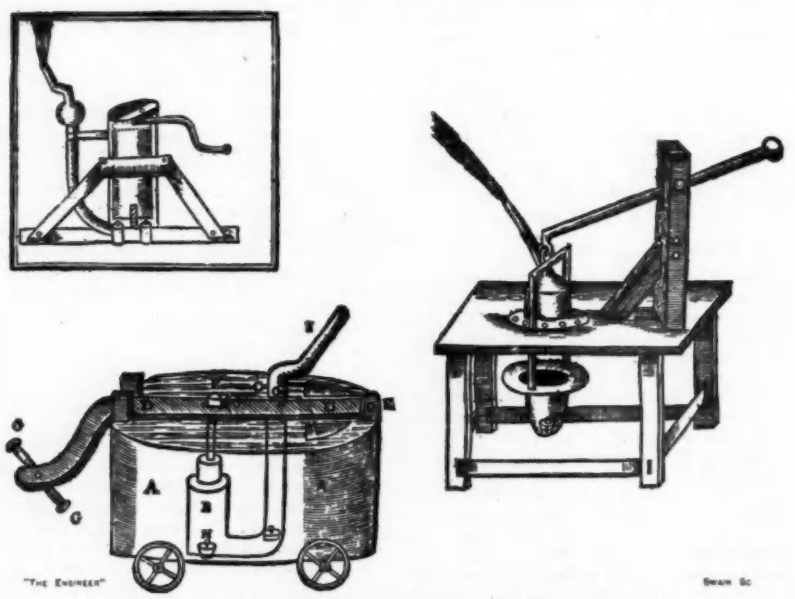
A second and enlarged edition of Bate's book appeared in 1635. This includes a chapter devoted to fire engines, in which he describes—"first, such as I have seen used, then such as I conceive to be no lesse usefull than the former." Little or nothing is known about John Bate, but his book contains nothing to suggest that he ever went abroad, and it is fair to assume that such engines as he had seen he had seen in London, and that they were made by Burroughs under Jones's patent, which was still in force.

The first two engines described are the bellows pump just referred to. They differ only in that one is worked by a single sweep or hand lever, while the other has two separate hand levers. This last form Bate explicitly states that he had seen used. He does not like it so well as the other, "because that this being wrought upon by two severall persons, they cannot alwayes keep a just time one with the other in fetching their stroakes, but they will strike sooner sometimes, and sometimes later, the one than the other."

It is evident that Bate himself favoured the cylinder and piston, for the five remaining forms that he gives are of this construction. The first is a force pump with a vertical cylinder and the forcer coupled directly to a hand lever extending across the cistern; it seems to be the same design as the Nuremberg engine shown by De Caus. Bate does not say that he had seen this engine at work, but it is probable that he had. The next engine has a single horizontal cylinder; the third has a vertical cylinder with the forcer worked from below; the fourth has two horizontal cylinders, with the forcers worked by arms on a vertical rock shaft; and the fifth again has a vertical cylinder, but here the forcer is made heavy and performs the down stroke by its own weight, being then pulled up by a rope fixed to a pulley on a shaft furnished with a hand wheel.

The amount of space devoted to the subject in Bate's book suggests that at the time the fire engine was receiving a considerable amount of public attention.

We have seen from Fuller's remarks that up to about 1660 Burroughs had made some sixty engines. By the year 1666 his number must have been still higher, and by this time the patent having expired,



FROM "MYSTERIES OF NATURE AND ART" BY JOHN BATE, 1634-1635

he was not the only maker. Fromanteel, the clockmaker, was in 1658 advertising that he made engines "in a new way of his own invention for quenching of fire, which have been thoroughly proved, and found to be effective . . . they are not subject to choak with mire, and when they are clogged with Dirt, may be cleansed without charge, in half a quarter of an hour's time, and fit to work again."[4] Then there was John Shawe, the founder at the Dial in Lothbury, who in 1665 supplied engines to the Corporation of Reading,[5] and probably made some for use in London.

* Newcomen Society, November 26th, 1930.—Abstract.

[1] Besson, "Théâtre des Instruments Mathématiques et Méchaniques," 1578.

[2] Cyprian Lucar, a treatise named "Lucarsolace," 1590.

[3] Lupold von Wedel's "Beschreibung seiner Reisen," &c., 1561–1606. "Gesellschaft für Pommerische Geschichte," 1895 page 348.

[4] The *Commonwealth Mercury*, November 18th–25th, 1658.

[5] Hist. MSS. Comm., Reading Corporation MSS.

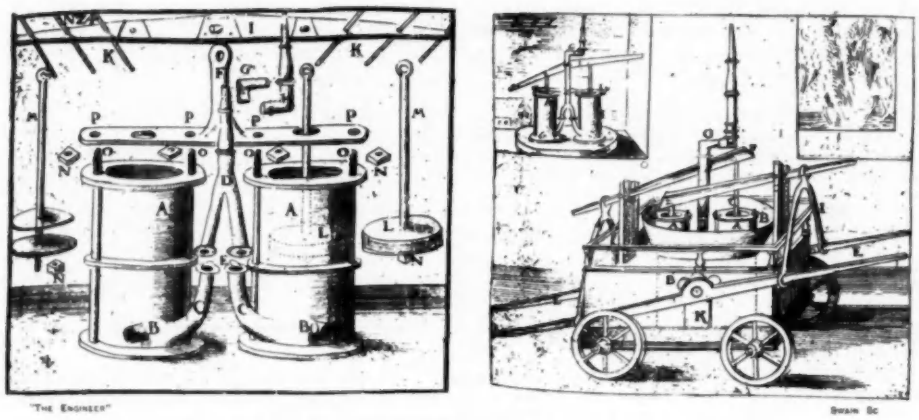
Again, in the same year, 1665, we have Henry Robinson seeking a patent for his invention for quenching fire.

On the whole, then, there must have been a considerable number of parish engines in London when the Great Fire broke out in 1666. The question arises, Why did they play so small a part in quelling the outbreak.

The matter of dealing with fires was a parochial one, and, while some few parishes kept their engines in order and ready for work, there can be no doubt that in many cases there was no organisation to take charge of and work them, and they were not fit for prompt use when occasion arose. But beyond this, these early engines were heavy, clumsy things, and no doubt deficient in many respects. There was always the difficulty of keeping them supplied with water; moreover, being unprovided with delivery hose, unless brought into service when a fire first broke out, they were quite unable to cope with it later.

The engines of this period were not provided with delivery hose; nor had they suction hose or air vessels.

The patent to Wharton and Strode in 1676 marks the introduction into this country of leather hose. It is for "certeine engines with leather pipes for the raiseing of water for quenching fires, drayneing of mynes and drowned lands," &c. The invention



"The Engineer" Swain Sc

FROM "THEATRUM MACHINARIUM" BY ZEISING. 1612-1614

originated with Jan and Nicholas van der Heyde, at Amsterdam, about the year 1670.

The introduction of wired suction hose seems to be marked by Lofturgh's patent of 1690, for we find an entry in the Calendar of Treasury Papers for the same year to the effect that iron wire is absolutely necessary for making his engines. Here, again, the invention came from Holland. It appears to have been due to Jan van der Heyde the younger, and was brought to this country by J. L. and Nicholas de Wael.

The air vessel, although it was described in the "Philosophical Transactions" in 1676, did not come into use for many years. We usually associate the name of Newsham with the application in practice of this device, and certainly about 1740 it was one of the features of his engines. How long before this he had been using it is not known. In his first patent, of 1721, he says that his engine produces "a continued stream without intermission"; but he obtained this result by means of "a new fashioned worm which works without racks on ladders, so fixed that one forcer begins before the other hath left forcing." Clearly, he was not using the air vessel at this time. Perhaps it was already in use by some other maker, as by Fowke, who made what he called "constant streamed engines," and he was trying to produce something different. At this period Newsham describes himself as a pearl-button maker, and his first engine was probably a rather crude affair. He describes it as "working with more winches or cranks on the outside than any other water engine heretofore made; a new contrived winch or crank in imitation of a crane, called a crane crank acts with a double motion, and hath a new invented clack with four half-wheels." This is not very intelligible, but Newsham stuck to his task, and his second patent of 1725, in which he says that after much experience he has made considerable improvements, includes features which characterise his well-known engines. The engines are made long and narrow, the pumps are worked by long handles, extending along the sides, and also by treadles extending along the top of the engine, and the forcers "are guided by the arch of a double wheel and chains on racks and teeth which cause a perpendicular stroke." Nothing is said about a continued stream or an air vessel, nor of flexible hose or a suction pipe. But when we come to his trade circular of a few years later—given in Switzer's "Hydrostaticks and Hydraulicks" (1729)—we find that his engine "carries continual streams with great force," and as he had now given up the "new fashioned worm" of his first patent, it is quite possible that he got the continual stream by the aid of an air vessel. The circular informs us also that the water may be played either from the engine or a leather pipe or pipes of any length required, and the price of the leather pipes, each 40ft. long, with a pair of brass screws, is given for each size of engine. Moreover, we find the provision of a cock by means of which the pumps may draw from the engine cistern or from an external supply, and the price list gives the cost of the engines "without suction" and "with suction, and 6 foot of sucking pipe included."

The engine in the form in which Newsham left it—he died in 1743—is described with very clear drawings by Desaguliers—"Experimental Philosophy," Vol. 2—and that author notes an interesting point in Newsham's practice, *i.e.*, he worked his pistons out beyond the ends of the cylinders to avoid chambering, which was found to occur even with pistons of soft leather. In another part of the same work we read of "engines to put out fires, which have no air vessels, like the Dutch engines, or old parish engines," which suggests that at this date all the London makers were applying the air vessel. On the other hand, what is described as the "common squirting fire engine" in Clare's "Motion of Fluids" (1735), has no air vessel, and it has a lifting pump, whereas all the engines before referred to had force pumps.

There can be no doubt that Newsham's engine took the leading position very early—it is the only fire engine described in Emerson's "Mechanics" of 1754—and it continued to be made without substantial alteration for many years.

This paper does not profess to have covered the entire field of fire engine making, even in England, for the century or so that has been considered. Contemporary with Newsham we have Fowke, whose name has just been mentioned, and William Deane. An earlier maker was John Keeling, who issued a print of his engine in 1678; at about the same period Sir Samuel Morland, who was having his pumps made by Isaac Thompson in Great Russell-street, was offering to supply fire engines, but we do not hear of one of his make being used at a fire. However, so far as the writer is aware, no information is extant as to the construction of the engines supplied by these makers.

APPENDIX.

The Patent Granted to Roger Jones, 26th February, 1625.: Abstract from the Patent Roll No. 2329, 22 James I., pt. 6, No. 12.

"John Jones of London merchant in his travailes beyond the seas hath found out and discovered and he and Roger Jones his brother by their greate industrie and paines and att their greate costs and charges have perfected a newe profitable and commendable invention art or skill and way of making and using an Engine or Instrument artificiallie wrought with scrues and other devices made of Copper or brasse or other metall for the casting of water, with a spout of Copper or brasse or other metall into any house shippe or other place taken with fire in such a manner that with the helpe of tenne men to labor at the said engine or instrument water may be cast into any house, shippe or other place taken with fire in such abundance and with such violence that it will quench the fire with more ease and speed then five hundred men with the helpe of Bucketts and ladlers can performe without it and that without danger to these that shall labour about it and with that certaintie and assuredness that the fire by Gods blessing shall not spreade to the endangering of the houses or places adjoining which nowe are preserved onlie by pulling them downe to their utter destruction and the danger of manie mens lives, which said engine or instrument (as we are informed) hath not heretofore beene knowen or putt in practise and brought to perfection within anie our Realme and Dominions. But nowe our loving subjects which shall have occasion to use the said Engine or instrument may receive greater ease and safetie then by anie other meanes which hath bin heretofore used for the quenching or preventing of fire, as hath bin found by experience uppon an occasion of a fire latelie happened in the dwelling house of James Demetrius, Brewer, in St. Katharines neare the tower of London."

The document proceeds to confer upon Roger Jones, with the consent of his brother John, the sole right of making, vending, and using the invention, or any imitation thereof, in England, Ireland, Wales, and the town of Berwick-upon-Tweed, for fourteen years. It forbids importation, and gives the right of search for, and seizure of, infringing engines. Towards the end is a clause that the patent is to be held good "notwithstanding the not mentioning or not describing of the engine. . . . or of the certaintie of the forme of the engine." On the other hand, the patent is not to be used to prohibit the use of anything that was in use before the date of the grant, or anything which shall be new invented hereafter.

The Heating and Drying of Granular Materials by Convection.

By W. GILBERT, Wh. Sc., M. Inst. C.E.

No. IV.*

COAL DRYING IN THICK LAYERS.

THE apparatus used, in the first instance, for blowing hot air through thick layers of coal is shown in Fig. 20. Three circular containers were provided, each capable of holding a coal layer 4in. in diameter and 6in. deep, and forming, together, when required, a total depth of 18in. The coal was supported in each container by a sieve wire base of suitable mesh. Asbestos lagging, 1in. thick, was provided circumferentially. The lower cylinder was placed on the outlet bush of the experimental drying apparatus—see Fig. 2, November 7th—from which hot air, at a known temperature, was supplied at a measured rate.

After passing the coal layers the exit air temperature was measured by a multiple bush. Each cylinder

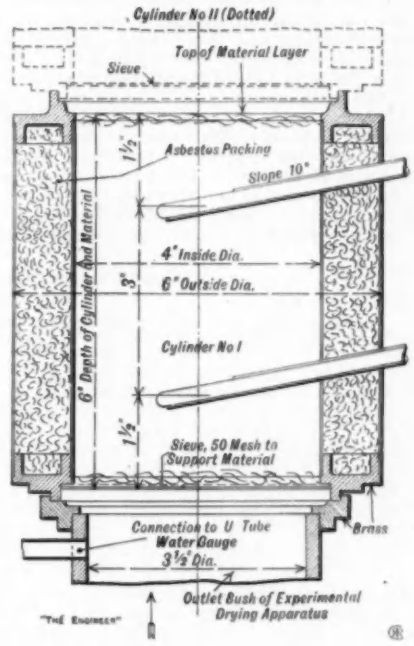


FIG. 20—COAL DRYING APPARATUS

rested on a faced joint ring, the weight being sufficient to prevent leakage of air.

Experiments were first made with one container, using grade V.—see Fig. 21—coal. After being charged with damp coal, the container was weighed on a fairly delicate balance. It was then placed in position, and hot air was blown through for a definite period, after which the container was removed and again weighed, the loss of weight being taken to represent the moisture evaporated.

To measure the temperature of the coal at any period, mercury thermometers were inserted as shown in Fig. 20. The bulbs were supported on the underside by a half tube of thin copper. It was found later that the thermometers measured approximately—but not accurately—the hot air temperature, instead of the coal temperature.

Several experiments were made with one container, also with two and three containers in series. On

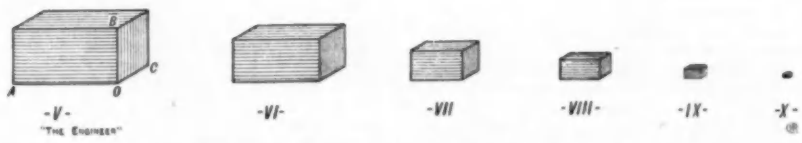


FIG. 21—AVERAGE LUMP SIZES OF COAL SAMPLES—HALF SIZE

grade V. coal rapid drying was obtained, but since the average coal temperature at any depth in each container was not known, a heat balance could not be drawn up, nor the value of the convection constant H_c be determined.

The water gauge, or air pressure required, when using one, two or three cylinders, was proportional to the thickness of the coal layer, and the same proportion was found to hold for a coal layer only 1in. thick, with lumps of the largest size—grade V.—in use.

Hence it was decided to make the remainder of

* No. III. appeared November 21st.

the experiments on coal layers 4in. in diameter and 1in. thick, the advantages being that at any instant the average lump temperature would not vary greatly throughout the layer, and the average temperature of the whole layer could be determined, when required, by a water calorimeter. A calorimeter large enough to receive a layer of coal 4in. in diameter and 1in. thick was accordingly made.

One container was shortened as shown in Fig. 22. A lid was provided, the circular opening in it being closed by a wire mesh, similar to that at the base. Handles were placed on the container and on the lid, and by suitably grasping them the apparatus could

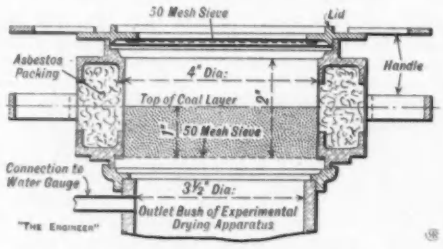


FIG. 22—SHORTENED CONTAINER

be quickly lifted off the outlet bush of the experimental apparatus, be reversed and replaced, so that the hot air passed through the coal layer in the opposite direction, and the relative position of all the particles was altered. The upper side of the lid was provided with a faced ring similar to that at the base of the container.

Coal Drying in 1in. Layers.—The 1in. layer experiments were made on another class of bituminous coal—labelled H.—the natural, or contained, moisture being about 15 per cent. The lumps of the grades selected for illustration are shown half size in Fig. 21.

Typical experiments are summarised in Table No. IX. In any experiment one grade of coal only was used, so that the lumps, or particles, were approximately of the same size, and calculations were thus facilitated. A selection of the graphs illustrating the experiments, which are here given, are listed in Col. 7 of Table IX.

The chief result of the 1in. layer experiments, which were all made with a hot air temperature of 320 deg. Fah., is to show that up to, and including, grade VII. coal, the method of drying by blowing hot air through a thick layer is effective. If W is constant, the value of H_c, however, falls off as the particle size is reduced—see Cols. (2) and (6). For the smaller grades it is apparent that the hot air did not come properly into contact with the total surface of the coal.

In the experiments on coal-drying previously described, in which isolated coal lumps or particles were fully exposed to the hot air current, results essentially different were obtained. The rate of heat transmission per square foot of surface per degree Fah. rapidly increased as the particle size was reduced—see Fig. 14, November 14th.

The general method of making the experiments may be described with reference to graph W—Fig. 23—which relates to grade V. coal, the value of W used being 940. This rate of hot air supply is estimated on the full area in cross section of the container, 4in. in diameter. The actual air velocity between the particles would, therefore, correspond to a much larger value of W.

The coal was soaked for not less than 48 hours, and then centrifuged before each experiment. Enough was weighed out to form a layer 1in. thick in the container. The method of obtaining the evaporation curve and the average temperature curve was essentially the same as for the fully exposed experiments on coal, and need not be again described.

After completing the experiment and plotting the evaporation and average temperature curves, the graph is analysed in order to obtain the average value of H_c from the commencement to the time when the coal is 95 per cent. dry. Referring to Table X., the graph is divided into periods (0–1), (1–2) and (2–4) minutes, &c., and the heat supplied to the coal in each period is calculated. It is convenient to base the calculations on 100 lb. of wet coal, so that the figures in the table relate to 84·45 lb. of dry coal and 15·55 lb. of water.

Considering the period (0—1), Table X., the figures in Cols. (2) to (6) are readily obtained from the graph.

Col. (7) gives the heat required to raise 84·45 lb. of coal through the temperature range 60 deg. to 183 deg. Fah.

Col. (8) shows the heat used in raising 10·8 lb. of water through a similar temperature range.

Col. (9). It is assumed that the moisture—4·75 lb.—is raised in temperature to 212 deg. Fah., then evaporated, and finally superheated to the surface temperature of the coal. Since the latter is not known, an approximation is made.

Col. (11). The coal surface—see Table IX., Col. (5)—is $84·45 \times 2·62 = 221$ square feet, and the period one minute. Hence, the figure required is

$$\frac{10,160}{221} = 46·0$$

Col. (12). Since the calculations relate to 100 lb. of wet coal, a corresponding value has to be found for the weight of hot air used per minute. In the present experiment, W=940, and the actual weight of hot air used per minute, with a container 4in. in diameter, or 12·57 square inches in area, was

$$\frac{940 \times 12·57}{144 \times 60} = 1·37 \text{ lb.}$$

(It will be remembered that both W and H_c relate to quantities per hour.)

The average weight of the wet coal layer, 1in. thick, was 0·309 lb.; hence, the equivalent weight of hot air per minute which would correspond to 100 lb. of wet coal is $\frac{100}{0·309} \times 1·37 = 442$ lb.

If Tf is the average fall of the hot air temperature during the period (0—1), and 0·24 the specific heat of the hot air, we have

$$442 \times 0·24 \times \text{T}f = 10,160$$

and

$$\text{T}f = 96 \text{ deg. Fah., as listed in Col. (12).}$$

Col. (13). The average exit gas temperature for the period is 320—96=224 deg. Fah.

Col. (14). The average hot air temperature is $\frac{320+224}{2} = 272$ deg. Fah. This value of the average hot air temperature is set up at the centre of the (0–1) period, on the graph W and the curve marked III. is obtained.

Preliminary Calculation of H_c—Consider, for instance, the period (2–4) minutes on graph W, the rate of heat supply to the coal from Table X. is 11·47 B.Th.U. per square foot per minute. Taking the conductivity of coal at 1·42 (per square foot per hour per degree Fahrenheit per inch thick), it can be calculated that the surface temperature will exceed the average temperature at 3 minutes by approximately 24 deg. Fah. Hence, the surface temperature is 249+24=273 deg. Fah.—see point S on graph W—and the temperature difference (hot air and coal) is 308—273=35 deg. Fah.

So that

$$H_c = \frac{11·47 \times 60}{35} = 19·7$$

This is a preliminary calculation. Based on the figures listed in Table X., the average value of H_c for the heating period (0—9) minutes is deduced by a mathematical process to be explained later.

Specific Heat of H Coal.—Three determinations were made of the mean specific heat of H coal in the copper furnace, over the range 320 deg.–60 deg. Fah. The results were as follows :—

Grade V. coal	0·3536
Grade V. coal	0·3524
Grade VII. coal	0·3488
Average value	0·352

Agitation of the Coal Layer.—Observations were made during the experiments on each grade to find out if a certain amount of agitation of the particles—such as they would receive in various forms of layer driers in practice—would accelerate the rate of drying. This was done by reversing the container at regular intervals during the progress of an experiment. A rapid shake was given to the charge before replacing the container on the outlet bush. The loss of heating time was allowed for. Up to and including grade IX. there was no advantage, but for grade X. coal, which contained, after being centrifuged, 18·42 per cent. of water, there was a tendency for the particles to cling together, and the sudden reversal and shaking of the container, at half-minute intervals, effected a decided improvement in the rate of evaporation.

Limiting Value of W.—It was found that if W exceeded a certain value, the upper particles of the 1in. coal layer began to be disturbed, and there was a tendency to blow air holes through it.

The following table gives the approximate value of W, when the disturbance commenced :—

Grade.	Limiting value of W.
VIII.	800
IX.	300
X.	74

Some of the experiments on the smaller grades listed

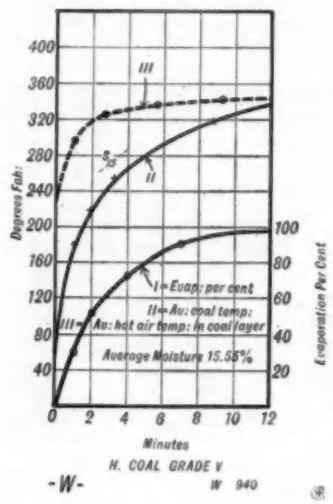


FIG. 23

in Table IX. were therefore made under rather unstable conditions, but the sieve wire lid over the container prevented any particles of coal from being blown out.

Air Pressure Required.—The experiments so far described relate to the drying of separate grades of coal. If a mixed sample of coal is dried, as it would be in practice, the presence of fine material increases the water gauge required to force the hot air through the layer.

The maximum value of W which may be used is of importance, since it represents the rate at which heat can be supplied. Consequently, experiments were made on rotary kiln coal, limestone, rotary clinker, and standard sand in order to determine the relation between W and the thickness of the layer, the grade of material, and the water gauge required. For this purpose one container was used, as shown on Fig. 20.

The material was filled in, 6in. deep, and cold air was blown through at definite rates, from the outlet bush of the experimental drying apparatus. The water gauge required was measured by a U tube water gauge, the connection to the underside of the layer being made as shown in Fig. 20.

TABLE IX.—*Layer Drying Experiments, Summary of Results.*

Grade of coal.	Value of W.	Moisture in raw coal, per cent.	Time required to dry out 95 per cent. water (minutes).	Surface per pound dry coal, square feet (H. coal).	Average value of H_c (as calculated).	Graph reference.	Value of $\bar{x}$.
V.	940	15·55	9·0	2·62	22·3	(W)	0·0501
V.	716	15·64	12·8	2·62	13·5	—	0·0501
V.	376	15·13	13·5	2·62	8·72	(X)	0·0501
VII.	658	15·07	8·0	4·91	11·30	(Y)	0·0271
VII.	376	15·15	12·0	4·91	5·70	(Z)	0·0271
VIII.	658	14·85	6·3	7·96	8·40	—	0·0140
VIII.	376	14·60	7·7	7·96	5·70	—	0·0140
IX.	376	14·84	4·5	16·35	5·50	(A a)	0·0081
X.	376	18·42	7·0	44·40	0·70	—	0·0039
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

TABLE X.—*Analysis of Graph* (W), *Grade V. Coal*, W=940.

Period on graph, Min.	Coal temperature, deg. Fah.			Evaporation in period, lb.	Water remaining in coal, lb.	Heat received by coal in B.Th.U. per 100 lb. wet.				Heat to coal per sq. ft. per min. B.Th.U.	Fall of hot air temperature, deg. Fah.	Average exit gas temperature, deg. Fah.	Average hot air temperature for period. deg. Fah.
	Initial.	Final.	Aver.			Heating coal, φ=0·352	Heating water in coal.	Evaporating water.	Total.				
0—1	60	183	121	4·75	10·80	3660	1330	5170	10,160	46·00	96	224	272
1—2	183	225	204	3·34	7·46	1250	313	3370	4,933	22·28	46	274	297
2—4	225	266	245	3·67	3·79	1220	155	3700	5,075	11·47	24	296	308
4—7	266	300	283	2·49	1·30	1010	44	2490	3,544	5·35	11	309	314
7—9	300	311	306	0·54	0·76	324	8	527	859	1·94	4	316	318
									24,571				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)

The results show that

(*a*) With a constant depth of layer the value of W is proportional to the square root of the corresponding water gauge.

(*b*) For a constant value of W, the thickness of the material layer is proportional to the water gauge required; a layer 12in. thick requiring twice the water gauge of a layer 6in. thick.

(*c*) If the value of W and the layer thickness remain constant, the water gauge required is proportional to the absolute temperature of the air, *i.e.*, the temperature in degrees Fah.+461.

Grading of Materials.—The limestone and rotary

kiln coal used for these experiments were separated into the usual grades by sieving. Details of the sieves are given in Table II.

Rotary Kiln Coal.—The result of the tests made on rotary kiln coal with air at 56 deg. Fah. are shown on graph A *b*, Fig. 24, where for a 6in. layer the value of W is plotted against the square root of the corresponding water gauge. For example, with grade VIII. coal, for W = 800, the water gauge required is $(2 \cdot 2)^2 = 4 \cdot 84$. The point marked "limit" denotes that at this value of W the material tended to rise up out of the cylinder. With the smaller grades of material this point was reached at a correspondingly lower value of W. It will be apparent both from the low rate of heat transmission to the smaller particles and their resistance to the passage of air, that layer drying is likely to be effective for lumps of ¼in. size or upwards, but not so effective for the smaller grades of material.

Limestone.—Graph A *c*—Fig. 25—shows the relation between W and the square root of the water gauge, with air at 58 deg. Fah. for grades of crushed limestone 6in. deep, and also for a 6in. layer of mixed crushed stone, as it occurred in practice. In this particular sample 6·3 per cent. of the material passed through the 20-mesh sieve. The lumps were mainly from ¼in. to 1in. in dimension.

Rotary Clinker.—The tests made with cold air on a mixed sample of rotary clinker, as received from the kiln, give a line which closely corresponds to that for mixed limestone on graph A *c*.

Standard Sand.—As is well known, standard sand passes a No. 20 mesh and is retained by a No. 30 mesh sieve; its particle size therefore approximates to grade X. It proved very difficult to get air through this material. For a value of W = 200, the water gauge required for a 6in. layer of dry sand was 7·05in. The limiting value of W was 238, when the sand tended to rise out of the cylinder. The tests were made with air at 58 deg. Fah.

(To be continued.)

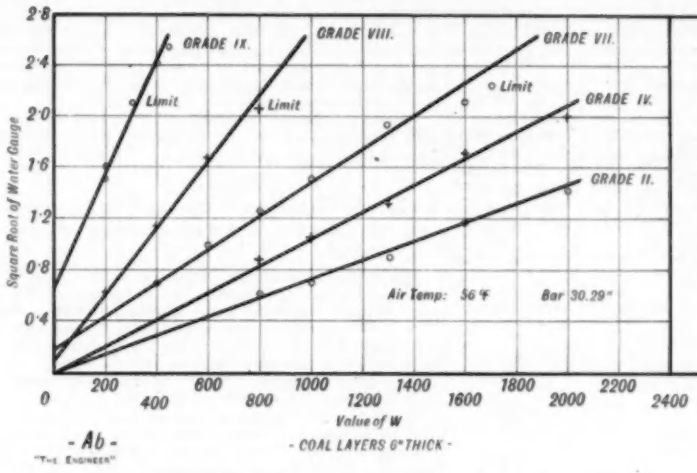


FIG. 24—RESULTS OF TESTS WITH ROTARY KILN COAL

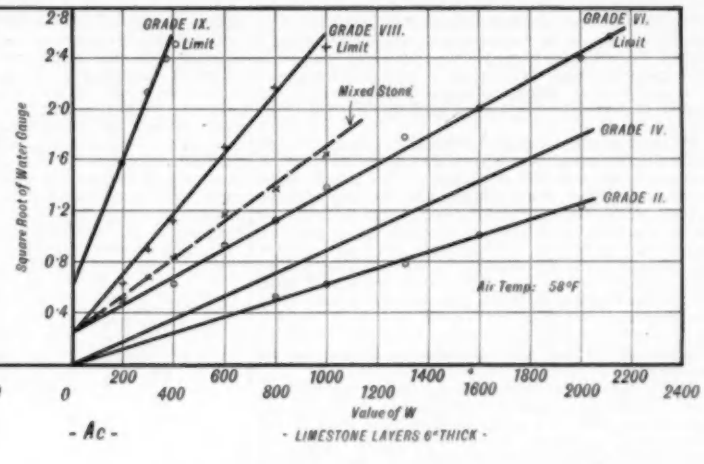


FIG. 25—RESULTS OF TESTS WITH CRUSHED LIMESTONE

The R 101 and the Altimeter.

By Colonel SIR GORDON HEARN, C.I.E., D.S.O.

THE Committee of Inquiry into the loss of the "R 101" stands adjourned. The evidence is being digested, and further proceedings will endeavour to eliminate the improbable causes and to accept the most probable cause as the correct one.

One of the possible causes was the failure of the altimeter, or, alternatively, a wrong inference drawn from the indications given by the altimeter. Being particularly interested in this portion of the evidence, the writer attended the inquiry on November 4th, when Dr. Simpson, the meteorological expert, was examined. The Great Hall of the Institution of Civil Engineers is not ideal for hearing, in spite of the loud speakers provided. Questions to the witness are not always addressed to the microphone also. Conferences over charts were inaudible, the only indications of the results being short summaries addressed by Sir John Simon to the shorthand writer. A mass of technical evidence was evidently mastered by Sir John, whose questions, with one exception, indicated a wonderful grasp of the subject.

Dr. Simpson, very naturally, was rather concerned to show that the organisation of the information service was efficient. It appeared that in many respects there was little wanting, although the writer will propose later that further information should be given. Forecasts, apparently, are made every six hours, and the ship sailed with information not more than two hours old. A depression was advancing from west to east. The result was to lower pressure over France, so that while the ship at the moment of sailing might have entered into an area of gradually increasing pressure gradients, actually at the moment of crashing the calculated mean sea level pressure for Beauvais was the same as the calculated pressure at the time of starting from Cardington. Some hours earlier and some hours later there were notable alterations of pressure. The "Graf Zeppelin" undertook a short cruise a little later. Dr. Eckener found that his altimeter registered an alteration of height of some 400ft. on returning to his base. However, after correspondence, he agreed with Dr. Simpson that such a state of affairs could not have developed in the area traversed by the "R 101" at that time.

The Committee was not inclined apparently to attribute responsibility for the crash to the vagaries of the altimeter. At the same time, there are certain disquieting facts which merit attention. The navigator, in his wireless message, gave the height of the ship when 15 miles south-west of Abbeville as 1500ft., but the evidence indicates that this was an over-estimation. It is extremely difficult for a ground observer, trained or untrained, to give a reliable estimation of height, but the unanimity of the evidence seems to prove some over-estimation. It is not clear whether a height of 1500ft. meant that height above sea level or above the rapidly changing height of the ground. The bottom layer of the cloud mass, not very dense, lay less than 1000ft. above the ground, and the ship was running below the cloud. The navigator gave the air temperature as 51 deg. Fah., and it was found that the ground temperature was 57 deg. Fah. at the place passed over and at the time of passing. The conditions did not indicate any departure from adiabatic conditions. The conventional rate of change of temperature with height is 2 deg. Cent., or, say, $3^3/_5$ deg. Fah., per 1000ft. Dr. Simpson appears to have assumed a rate of 3 deg. Cent. in calculating the height above ground of the navigating cabin at about 1100ft. The ground is there about 100ft. above sea level. An error of 300ft. or 400ft., whichever it may have been, is important. If not due to altimeter error, the difference may have been due to miscalculation or to a wrong setting of the altimeter at the start. Dr. Simpson calculated that meteorological conditions might have induced an error of 75ft., or if the navigator made certain—unspecified—calculations, the error might have amounted to 168ft. It did not transpire whether the altimeter was recovered undamaged after the crash and the fire. The height of the ground at the point of crash was understood to be 250ft. above sea level, so that there would have still been "air room," had it not been for the diving mentioned in the evidence of the survivors. An over-estimation of height would not have caused alarm—at all events during the first dive, if it could be checked.

The writer has no experience of airship handling, and can only suggest that a diving tendency may take longer to correct with tail elevators than by nose elevators. His experience of ground levelling by altimeter, with considerable success, enables him to appreciate the difficulty of air navigation, in so far as it is necessary to know the height of the aircraft above the ground. No doubt the Air Ministry knows all there is to be known about this subject. At the inquiry Dr. Simpson produced a thick sheaf of "Flying Instructions," the contents of which were not disclosed, but which, it is to be hoped, may be reproduced in the "Proceedings" for the benefit of surveying engineers.

The captain of a sea-going ship is concerned, not only with direction by compass and speed through the water, but also with the depth of water under his keel. To guide him he has charts and tide-tables which predict with great accuracy. In case of doubt, he can use the lead, deep sea or hand, or the ship may be provided with an echo sounder. An echo sounder can be fitted to an airship, but the ground level is rapidly changing at the high speeds, and the weight is believed to be considerable. The airship navigator is mainly dependent on the altimeter.

In a series of articles, commencing with the issue of THE ENGINEER for March 9th, 1928, the theory and practice of ground surveying by altimeter was dealt with at length by the writer. Here it is only necessary to repeat that the altimeter is an aneroid barometer, graduated to feet on a conventional scale, for an arbitrary pressure at mean sea level, and for an arbitrary adiabatic variation of temperature of the air column. If the mean sea level pressure varies or if the temperature lapse rate varies, or both, or if the air conditions are not adiabatic, then the setting of the altimeter at starting will mislead. Even at starting, if the altimeter is set to the height of the air port or of the mooring tower, an error will be introduced, if there are not the same temperature conditions as are assumed when graduating the instrument. Practically, the conditions are never the same.

Sir John Simon stated one source of error clearly when he asked the question: "If the pressure at starting is 30in., and later becomes 29in., then the altimeter shows the aircraft flying 1000ft. higher than is really the case?" Unfortunately, this may have been the cause of the loss of life in Transatlantic flights. Apart from ice forming on the wings, the altimeter may have given a wrong indication of height in meeting a depression. In England last December with fine weather continuing and no sign of danger, the barometer fell nine-tenths of an inch. The attempted flight to the Cape in December, 1929, failed through flying into a hill during a storm in the Mediterranean.

Greater safety of navigation would be attained if ground stations communicated pressure and temperature conditions, as well as wind and weather conditions. It would be unprofitable to suggest how this should be done, but ships should assist in the work. It would require international agreement, which would only be sought if the principle is accepted. Before agreement is sought, probably a larger number of aircraft will be making long-distance flights. It would be of advantage in aerial surveying also, but not of such importance because ground control can be applied. The latitude and longitude of well-marked features on the photographic strip can be ascertained by the prismatic astrolabe and otherwise, so that the scale can afterwards be corrected by other modern instruments, more or less automatic. There seems no possibility of making the altimeter register a general change in pressure or temperature conditions automatically.

Tubes for High-Pressure Water-Tube Boilers.*

By S. F. DOREY, M.Sc., Wh. Ex.

(Concluded from page 568.)

SECTION III.

MATERIALS FOR TUBES.

So far, for water-tube boilers, there appears to be no necessity for departing from the use of low carbon steels, but undoubtedly there is a call for the soundness of steel used in the manufacture of tubes and reliability against segregation, and the troubles that arise from it, most prominent amongst which is corrosion.

Tubes for water-tube boilers are usually specified to be cold drawn under 1½in. dia., and weldless, and manufactured from steel made by the Siemens-Martin open-hearth process, the percentage of sulphur and phosphorus being stipulated not to exceed, say, 0·025 and 0·03 respectively. The tests specified by most authorities consist of tensile, flattening, crushing, and bulging or expanding tests, together with hydraulic pressure tests. With regard to the tensile tests some authorities quote a maximum strength without a minimum, others a minimum strength or a range of strength, the limits being for ambient temperatures. The tubes are also required to be free from surface defects, which, incidentally, may be inherent in the material or caused in the process of manufacture. Frequently the material is required to comply with a chemical specification, but this may be no guarantee that certain of the constituents are evenly distributed throughout the material, and it is this lack of homogeneity which causes corrosion.

* Institute of Marine Engineers, Tuesday, November 11th. Abridged.

The most easily detected segregates are those due to the presence of sulphur in steel which occurs as sulphide of manganese or the double sulphide of manganese and iron, and these sulphides show up best by sulphur printing.

The association of corrosion and pitting in tubes with the presence of segregates has been convincingly dealt with by Messrs. G. R. Woodvine and A. L. Roberts in a paper entitled "The Influence of Segregation in the Corrosion of Boiler Tubes and Superheaters"—Iron and Steel Inst., Vol. CXIII.

It would, therefore, appear desirable that all water tubes of mild steel should be made of homogeneous material, having a low sulphur content equally distributed throughout the material, and to ensure that this is the case, suphur prints should be taken from the original ingots or the tube billets. Further, to ensure absence of hair lines on the outer surfaces of tubes, the tube billets should be machined to remove any mill scale. Similar remarks will apply to superheater tubes where mild steel is used, but as the working temperature is increased, it becomes necessary to study the behaviour of the material at elevated temperatures.

The high-temperature steam in contact with the inner surfaces of the tube is more likely to cause oxidation than hot gases in contact with the outer surfaces. In some cases, in order to protect the external surfaces of tubes from oxidation, the material has been coated with an alloy metal by means of a "calorising" or "aluminising" process. Experiments have shown, however, that with furnace gases having a CO_2 content above 12–14 per cent., the temperature at which oxidation commences is considerably higher than the metal temperatures likely in present practice.

Experiments carried out at the Royal Technical College, Glasgow, have shown that there is a slight dissociation of the steam with probable oxidation of the metal which may have some effect about 900 deg. Fah., but the pressure adopted in these experiments was comparatively low, and it is known that dissociation is checked by an increase in pressure. American investigations have also proved that, for mild steel, dissociation occurs at temperatures above 500 deg. Cent. It will, however, be shown later that considerations of strength limit the use of mild steel to temperatures not greater than 900 deg. Fah., so that with proper design and care to prevent excessive temperatures, serious trouble due to oxidation should not be experienced.

Some interesting particulars of experiments carried out to determine the resistance to oxidisation of heat-resisting steels are given in a paper entitled "Tubes in Steam Engineering," by Messrs. Robert Waddell and Laurence Johnson—Liverpool Engineering Soc., Vol. LI. According to these authors, high chromium irons and nickel chromium austenitic steels were unattacked by steam at 550 deg. Cent. and by furnace gases at 850 deg. Cent.

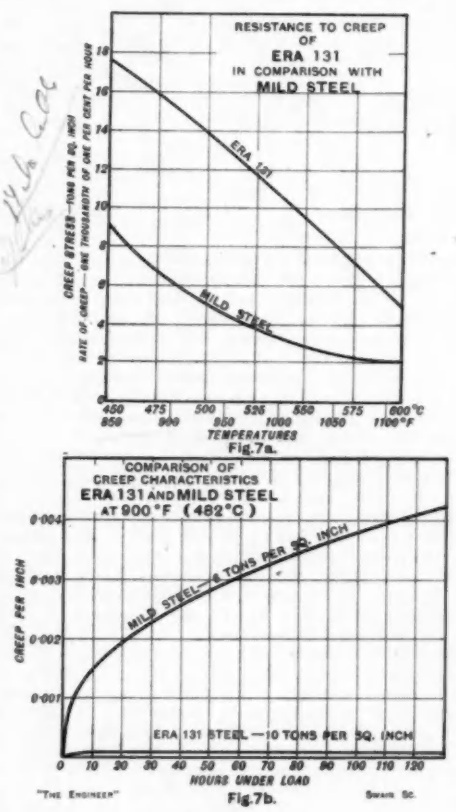
The approximate temperatures at which oxidation may start having been determined for any particular steels, it becomes necessary to consider the strength of the materials at these high temperatures. It has been found that at a certain temperature materials behave in a manner resembling a viscous fluid, and under stress deformation continues for various periods, depending on the intensity of stress. As a result, much research work has been and still is being carried out to ascertain whether there is a definite stress for each material and temperature at which deformation or creep ceases. Attention has more recently been given to the determination of the stress at which the rate of creep will not exceed a permissible amount, thus allowing for a known extension to take place for a given life, and the strength of the material is thus expressed in terms of temperature and time. In this manner it is found possible to use ordinary carbon steel at higher temperatures than has previously been thought desirable.

In order to ensure greater safety at high temperatures, steel manufacturers have investigated the alloying of certain elements, such as chromium, nickel, molybdenum, tungsten, vanadium, manganese, and silicon with ordinary carbon steels, so that increased strength will be attained. So far there is little available information of the behaviour of alloy steel tubes under service conditions, though there is a fair amount of information regarding their properties. The chief reason their use has as yet not become more general is on account of the highly increased cost. In some cases where it is necessary to use special alloy steels the cost can be reduced by dividing the superheater into two sections, consisting of mild steel tubes in which steam can be raised to a temperature of, say, 750 deg. to 850 deg. Fah. and the final superheating section consisting of the special alloy tubing in which the steam temperature is further increased to the required amount. Thus in the 1420 lb. pressure boilers at Mannheim power station, 3 per cent. nickel tubes have been used in the hottest parts. The advantages of the addition of small quantities of nickel, however, seem rather uncertain as regards superheater tubes. In this respect it may be mentioned that recent research indicates that the addition of low percentages of nickel has an adverse effect on the creep properties compared with ordinary mild steels. An alloy steel, known as "Enduro" metal, containing about 0·09 C, 0·34 Mn, 0·848i, 0·014 S, 0·021 P, 16·7 Cr, 0·19 Ni, has been tried for the last pass in certain superheaters in America, but, according to A. E. White—"Trans.," A.S.M.E., Vol. 51–1—this material appears to develop brittleness when held around 1000 deg. Fah. for a long time, and accordingly, owing to this property its use has been discontinued in some cases. The demand for a material which is strong at high temperatures and does not scale, has led to the development of high-nickel, high-chromium steels, which are austenitic in structure, and consequently can only be hardened by cold work. Most prominence has been given to an alloy of 19–18 per cent. chromium and 8 per cent. nickel. This material can be welded and machined, and tubes made from it will withstand the specified expanding, crushing and flattening tests. It has about twice the strength of low carbon steel at elevated temperatures, and, in addition, has a high resistance to oxidation. J. R. G. Monypenny, however, in *Metallurgia*, June 1930, considers that further investigation is needed before austenitic chromium-nickel steels can be recommended for use at 600 deg. Cent., as at this temperature the steels are particularly liable to intergranular attack by many corrosive media which have little or no action on them when they are in correctly treated condition. This seems to be borne out in practice, and the writer has been informed that while high-chrome-nickel alloy steel appeared at first to justify its use for high temperature service, failures have recently been experienced with this metal due to intercrystalline breakdown which gradually went on without giving any warning. In all cases no bulging or splitting of the tubes occurred, but failure was caused by a sudden breakdown of a large piece of metal from the tube.

It appears that the addition of small quantities of other elements gives improved properties, an alloy containing 18 per cent. Cr, and 8 per cent. Ni and 0·3 to 1·5 per cent. W, being considered the most satisfactory composition for withstanding high temperatures or chemical attack. Tests made by J. R. G. Monypenny, however, have shown that the addition of about 1 per cent. tungsten may retard the intergranular breakdown, but under certain conditions of chemical attack the steel is not immune from this defect. Unfortunately, the price at present is almost prohibitive, being not less than twelve times that of low carbon steels. Further, there is the likelihood of trouble in the fitting of austenitic steels on account of the difference of the coefficient of expansion from that of other materials, *e.g.*, expanding the tubes into headers. In certain cases, in order to prevent hardening or crystallisation, due to being expanded into headers, short lengths of ordinary mild steel have been welded to the ends of the superheater elements, thus preventing failure at the expanded joints.

The Foster Wheeler Corporation of New York have been carrying out experiments with a chrome vanadium steel, of which the following is an approximate analysis:—Cr, 0·85 to 1·05; Mn, 0·6 to 0·8; Va, 0·15 to 0·2; Si, 0·1 to 0·15; C, 0·17 to 0·22. This amount of vanadium is not sufficient to produce any vanadium characteristics in the metal, but acts as a scavenger and gives a very close grained metal which is exceedingly tough. Up to the present it is understood that tubes made from this steel have proved satisfactory in service, and have a much greater resistance to higher temperatures than have the ordinary carbon steel tubes.

In order to reduce cost and still have a greater factor of safety at high temperatures than that given by mild steels, attention has been devoted to the effect of small quantities of molybdenum and copper to low carbon steels. Two tube materials which have become more prominent recently on the Continent, and the price of which is stated to be about 50 per cent. higher than that of ordinary steel tubes, are manufactured at the Thyssen Works, and are known as "Th 30" and "Th 31." The approximate chemical analyses of these steels are:—For Th 30: M, 0·2 to 0·3 per cent.; Cu, 0·2 to 0·3; C, 0·08 to 0·12; Mn, 0·5; Si, 0·12 per cent., with P and S as low as possible. For Th 31 steel the carbon content varies from 0·16 to 0·18 per cent. The tubes are capable of withstanding the same mechanical tests as ordinary tubes. Th 30 can be welded, but for Th 31 the welding should be done by the oxy-acetylene process. Creep tests are not available at present, but the results of some comparative tests supplied by the makers, are given in the accompanying table:—


RESISTANCE TO CREEP OF ERA 131 IN COMPARISON WITH MILD STEEL
CREEP STRESS—TONS PER SQ. INCH
RATE OF CREEP—ONE THOUSANDTH OF ONE PER CENT PER HOUR
ERA 131
MILD STEEL
TEMPERATURES
Fig.7a.
COMPARISON OF CREEP CHARACTERISTICS ERA 131 AND MILD STEEL AT 900°F (482°C)
CREEP PER INCH
MILD STEEL—6 TONS PER SQ. INCH
ERA 131 STEEL—10 TONS PER SQ. INCH
HOURS UNDER LOAD
"THE ENGINEER"
Fig.7b.

FIGS. 7A AND 7B

Material.	Stretch limit, tons per square inch.		Ultimate tensile, tons per square inch.	
	400 deg. C.	500 deg. C.	400 deg. C.	500 deg. C.
Th 31	17·8	15·1	32·6	24
Th 30	11·9	10·8	25·8	19·2
3 per cent. Ni ..	14·7	9·5	26·9	15·9
Mild steel ..	8·1	5·5	20·5	11·7

The yield stresses stated in this table are not the stresses at definite yield points. Professor Korber has shown that for soft steels the yield point ceases at about 300 deg. Cent., so that it becomes necessary to adopt some criterion of minimum plastic strain. For practical reasons, he adopts a 0·2 per cent. limit, and the yield stresses given in the table correspond to what is known as 0·2 per cent. proof stress.

It is a little early to judge with any certainty how this tube material is behaving in boilers. The Vereenigte Kessel Works, Düsseldorf, have built a water-tube boiler fitted with superheater tubes of this material, the working pressure of which is 52 kilos. per square centimeter (740 lb. per square inch), the tubes being exposed to a temperature of 450 deg. Cent. (842 deg. Fah.). The time of guarantee has already lapsed, and it is stated that the firm intend to use these tubes in future for their boilers. Similar tubes have also been fitted in a Benson boiler which has recently been installed by Messrs. Blohm and Voss for experimental purposes in a cargo vessel owned by the Hamburg-Amerika Line.

A somewhat higher alloy carbon steel has recently been introduced in this country by Hadfields, Ltd., and is known as "Era 131." The writer is indebted to Hadfields, Ltd., for the following information:—Stated briefly, Era 131 steel, while maintaining a high strength in the range of advanced steam temperatures—750 deg. to 1100 deg. Fah.—has practically the same mechanical properties as mild steel at ordinary temperatures, and cold-drawn seamless tubes fully comply with the tests specified in B.E.S.A. Specification No. 53. It is claimed that the resistance to heat scaling is about half the rate of ordinary steel for equal temperatures, and that under long-continued heating—200 hours—at a temperature of 840 deg. Fah. it suffered no deterioration in its properties. Another advantage is that the coefficient of expansion is practically the same as that of ordinary steel.

The high resistance to creep of Era 131 steel, compared with mild steel—0·25 C, 0·75 Mn—is indicated in Figs. 7*a* and 7*b*.

Section IV.

Suggested Formulæ for Determining the Thickness of Tubes for High-pressure Water-tube Boilers.

Up to the present no authority in this country has issued rules for determining the thickness of tubes for high-pressure land or marine water-tube boilers. In the United States the American Society of Mechanical Engineers has issued rules, while rules are already in force for land boilers in Germany. For most high-pressure work in this country it appears that the thicknesses of tubes have been calculated in accordance with the A.S.M.E. rules.

After a careful study of the problem, and considering the thicknesses of tubes which have been used with satisfactory results in high-pressure boilers in this country and elsewhere, the writer suggests that the following formula might be used to ascertain the thickness of tubes for high-pressure water-tube boilers for marine purposes, viz.:—

$$t = \frac{\text{W.P.} \times d}{100} + x$$

where t = thickness of tube in one-hundredths of an inch;
W.P. = working pressure in pounds per square inch;
d = internal diameter of tube in inches;
x = factor depending on the position of the tube in the boiler.

For tubes not in the fire or subjected to the radiant heat from the fire

$$x = \frac{2000}{\text{W.P.}}, \text{ but not greater than } 7$$

For fire rows of tubes or tubes subjected to radiant heat from the fire, the value of x as given above to be increased by $\frac{2000}{\text{W.P.}}$, but not greater than 4.

For superheater tubes

$$x = \frac{2000}{\text{W.P.}}, \text{ but not greater than } 5$$

for steam temperatures not exceeding 850 deg. Fah. The usual practice is to specify outside diameters for tubes, in which case the formula becomes

$$t = \frac{5000}{\text{W.P.} + 5000}\left(\frac{\text{W.P.} + d_1}{100} + x\right)$$

where d_1 = external diameter of tubes in inches.

It will be observed that for any particular diameter of tube the value of the factor x decreases as the working pressure rises—that is, with increase in thickness. This is as it should be, since any reduction in strength due to wear and corrosion is proportionately less with thick than with thin tubes.

The curves marked X X in Fig. 2 *ante* show how the values of k obtained by using the suggested formula compare with the optimum values.

Section V.

Factors of Safety with Tube Thicknesses in Accordance with Suggested Formulæ.

The factors of safety for boiler and superheater tubes may be considered in two ways—(i.) on a stress basis, that is, margin of strength based on elastic limit, ultimate tensile strength or creep limit; and (ii.) on a temperature basis, that is, margin of temperature above which failure will take place due to the working stresses in the tube.

Boiler Tubes.—As an example of these two methods, the stresses for various pressures in 2in. o/d and 4in. o/d fire row tubes, having thicknesses in accordance with the suggested formula, will be considered. The temperatures of the inner surface of the tubes has been taken as 25 deg. Fah. above the corresponding steam temperature, and for the outer surface the temperature has been increased an amount determined by using equation (3) *ante*.

Figs. 8*a* and 8*b* show the calculated stresses at the inside and outside surfaces of 2in. and 4in. tubes respectively, plotted to a base of working pressure. The corresponding values of the limit of proportionality (P_L) for 0·17 carbon steel, taken from D.S.I.R. Reports Nos. 1 and 14, have been added, and the differences between the P_L curves and curves of tube stresses indicate the factors of safety, if P_L be taken as the criterion of strength. It will be observed that in the case of the 4in. o/d tube, the stress at a pressure of 1360 lb. per square inch coincides with the limit of proportionality.

The temperatures of the inner and outer surfaces of the tubes are also shown, together with curves of tempera-

ture margin. The temperature margins indicated are the difference between the temperatures of the tubes and the temperatures corresponding to the creep limits represented by the stresses in the tubes. It will be noted that even at the highest pressure shown there is a margin greater than 200 deg. Fah. This would be slightly reduced with tubes made of 0·10 carbon steel and also with higher heat transmission rates.

Superheater Tubes.—The foregoing methods may also be applied to superheater tubes where the temperature does not exceed 750 deg. Fah. Above this temperature, for low carbon steels, it is necessary to consider plasticity rather than elasticity, and this will be dealt with later.

When dealing with temperatures higher than 750 deg. Fah. for low carbon steels, it is now becoming recognised that in order to get the most from the material the stress distribution must be considered in accordance with plastic distortion, and in this connection much important and useful work has been done by R. W. Bailey, of Metropolitan Vickers Electrical Company, Ltd. The results of his investigations have been recently published in *Engineering*, June, 1930, under the title of "Thick-walled Tubes and Cylinders under High Pressure and Temperature," and it is now proposed to consider the case of superheater tubes subjected to high temperatures in the light of Bailey's treatment of the subject. Briefly, Bailey's experiments on thin-walled steel and lead tubes, subjected to compound stresses, and on a thick-walled lead pipe subjected to internal fluid pressure, gave no evidence of axial creep, from which it was deduced that creep was due to shear and hence was uninfluenced by normal stress on the plane of shear. The experiments also indicated that the torsional creep test provided a very ready means of deducing the creep behaviour of a tube under internal fluid pressure, and if ψ = creep rate in shear (radians per hour), and C = circumferential or diametral creep rate (strain per hour), then

$$\psi = 2\,C.$$

Owing to the small amount of data available regarding torsion creep tests, the variation of creep rate with temperature was considered to be similar to that found in tensile tests. The relations between stress and rate of creep, as determined by tensile tests, can be represented by the following two linear equations, in which (15) may be considered suitable for temperatures up to 500 deg. Cent., and (16) for higher temperatures :—

$$f^1 = a^1 + b^1 \log_{10} \psi \quad . \quad . \quad . \quad . \quad . \quad (15)$$

$$\log f = a + b \log_{10} \psi \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Tests carried out by Bailey have shown the diametral creep rate to be about one-half the rate given by tensile tests due to the influence of the axial load on the tube. Accordingly, the diametral creep rates indicated in the following have been taken as one-half the values given by Norton's tensile results.

Bailey then deduces expressions connecting the equations (15) and (16) with the stress in a thick-walled tube of internal and external radii r_1 and r_2 respectively, due to internal pressure p, which in the special case of a superheater tube is approximately given thus—

$$\log_{10} \frac{r_2}{r_1} = \frac{0{\cdot}2171\,p}{f} \quad . \quad . \quad . \quad . \quad . \quad (17)$$

where f is the shear stress at the outside of the tube, which under plastic conditions may be considered to be the same as the stress at the inside surface of the tube.

By means of equation (17) an approximate determination may be made of the value $\frac{r_2}{r_1}$ for any given condition of working pressure temperature and permissible creep rate. The value of the stress f for a rate of creep ψ equal in magnitude to twice the permissible diametral creep rate C can be obtained from the results of torsion creep tests at the service temperature.

In the case of a convection superheater tube the heat transmission rate is such that the temperature may for all practical purposes be considered as uniform across the wall thickness. Now values of $\frac{r_2}{r_1}$ for a superheater tube can be obtained by use of the suggested formula for the thickness of tubes, and since the working pressure and temperature are known for any particular case, use may be made of equation (17) to obtain the creep rate for the calculated stress f at any service temperature and the approximate life of the tube for a permissible deformation can be determined.

From the foregoing the life of the tubes can be approximately ascertained, and it will be apparent that if high superheated temperatures are to be used with the ordinary carbon steels available, the working pressures must be reasonable. A diametral strain rate of creep of 10^{-6} per hour, equivalent to ψ rate of 2×10^{-6} would result in a 2in. diameter tube becoming 2·02in. after 10,000 hours (417 days), which might be considered a satisfactory figure where high temperatures are considered desirable. With this rate of creep as a basis, the limiting pressures or temperatures for a metal can be deduced by the aid of equation (15) and creep test results.

Section VI.

Tubes in Service.

Defects common in medium pressure water-tube boilers might naturally be expected, and, to a greater extent, in high-pressure boilers. As regards their frequency, they occur in the following order :—Internal corrosion, external corrosion, distortion, cracking or splitting, overheating due to presence of scale or to blow pipe action of the flames. Some interesting particulars of experience with water tubes in a boiler operating at 1300 lb. per square inch at the Lakeside station, Milwaukee, United States of America, were given by John Anderson in a paper read before the Institute of Fuel in November, 1927. Trouble was first experienced due to scale, tubes becoming overheated, causing bulges about 1¼in. diameter and ¼in. high. These bulges were ultimately perforated, a small hole less than one-tenth of an inch in diameter opening up and allowing steam to blow into the furnace, but no splitting of the tube, with consequent explosive rupture, occurred. In other cases, blisters were formed on the tubes due to localised overheating. Having prevented further failures of this nature, trouble occurred due to rapid corrosion in fire row tubes, heavy internal deposits being built up in a short time, but with correct feed water treatment these difficulties were ultimately overcome. From information available, it appears that in high-pressure boilers split tubes or bulges which open do not generally lead to explosions, and frequently have only been traced by loss of efficiency or extinction of part of the fire.

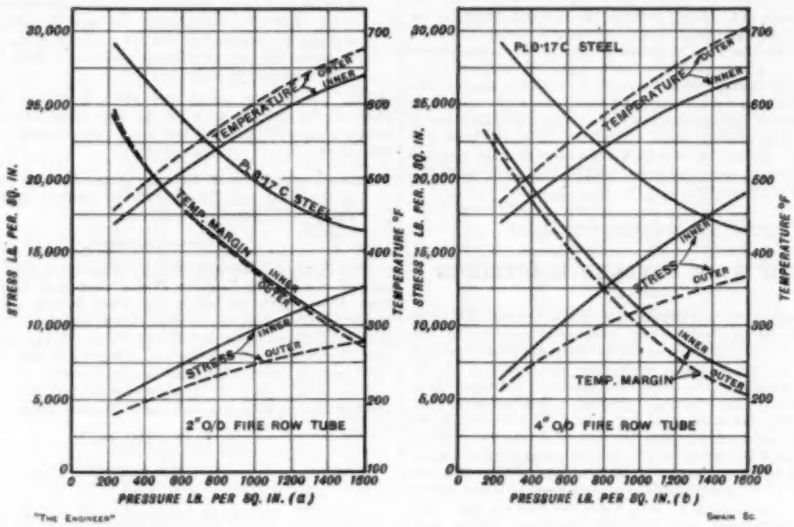
An interesting point which needs consideration in dealing with high temperatures is the degree in which the structure of the metal remains permanent, and if any change of structure takes place, its effect on the durability of the metal.

It is well known that the pearlite grains in carbon steels are made up of distinct parallel plates or lamellæ alternatively of ferrite and cementite, and if the metal be kept for a sufficiently long time at a temperature just below its critical range, say, 600 deg. to 700 deg. Cent., the cementite tends to collect in the form of rounded particles, which is known as "spheroidisation" of the cementite or "balling" of the pearlite. The effect of spheroidising is to decrease the strength and elastic limit of the steel and to increase its ductility and softness, the degree being more marked in high than in low carbon steels. Its effect would appear to be comparatively small for low carbon steels, and would be retarded by satisfactory annealing of the tubes subsequent to manufacture.

Conclusions.

An endeavour has been made in this paper to show that the stresses, temperatures, and factors of safety of tubes for high-pressure water-tube boilers can be ascertained with a reasonable degree of accuracy, and, given satisfactory material, there appears to be every indication that the reliability of tubes for high-pressure boilers should be equal to that obtained in moderate pressure boilers.

Undoubtedly, the successful operation of the high-pressure water-tube boiler depends largely upon the use of the most suitable material for the tubes. The special selection of material and the need for care during the process of manufacture and inspection cannot be too greatly emphasised. It is therefore considered desirable that in the first instance steel makers and tube makers should confer with one another with a view to drawing up a suitable specification for the billets from which the tubes are made. Later, engineers, boilermakers and tube makers might come together in order to formulate regulations for the thickness, testing, and inspection of tubes suitable for high-pressure boilers and high degrees of superheat.



FIGS. 8A AND 8B

A FABRICATED structural steel works is to be erected in Germiston, South Africa, as a branch of Dorman, Long and Co., Ltd.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE CURSE OF COMPETITIVE SELLING.

SIR,—Having been engaged for a number of years in the purchase of heavy machinery and stores for Government use in the Dominions, may I, through your columns, seek to throw some light on the case of trade depression and unemployment ?

When Cabinet Ministers and party leaders are "at their wit's end" to know what to do, and the reasoning of professors in political economy is lost in many words, it is time for a plain statement to be made.

The universal practice of sale by tender and acceptance of the lowest bid is the curse of modern trade. During the last twenty years, competition for orders for, say, cranes, has gradually become so severe that makers have had to sell below cost in order to get work. This practice is well known ; but only those firms with access to adequate capital can carry on the practice for any length of time. If sufficient orders can be secured, fixed charges can be spread over them and a small percentage charged to each. But with the present abnormally reduced demand, the difficulty of carrying on on these lines is obvious. It is essentially gambling with the future, so that by maintaining staffs and establishments they may be ready to take full advantage of the hoped-for revival of trade when it comes. But this practice only adds to the severity of competition, and many firms, already mortgaged up to the hilt, have had to sell up, with the consequent distress of employees and staffs.

The practice of buying in the cheapest market or the cheapest article on offer is a universal one, and one has only to visit a modern sixpenny bazaar to be impressed with the degree to which the masses are held in its grip. Manufacturers have no alternative but to meet this demand. Cheaper and ever cheaper products have to be turned out. To this cause may be traced the modern craze for mass production and distribution at the highest possible speed. High-pressure salesmanship, intensive propaganda, and ingenious advertisement have now been added to this endless process.

America has been very largely responsible for this excessive competition, and is a glaring example of its ultimate effects. Mass production was devised to create demand, but supply very soon far exceeded demand, and the only means of disposing of surplus products was the credit system on a large scale. Motor cars, radio sets, articles of domestic consumption and for household maintenance and repair, have been procurable on the easiest possible terms. It amounts to this, that the most successful salesman is the one who can offer the most generous terms to the public, who in this way have been encouraged to incur debts upon which there is the least possible security. In a word, vast quantities of machine-made products have been literally given away to the masses.

These debts have had to be financed, and reckless and thoughtless financiers have been ready to do this. Even shares in these "philanthropical" industrial concerns have been bought with money obtained on loan from bankers. The Federal Bank has advanced millions of dollars to support this fantastic business system, until at last the whole nation is in debt to itself. Untold millions which flowed into America during and after the war, together with the earnings of the multitude of workers, have been thrown into this bottomless abyss, and now endless numbers are clamouring for food. Millions of gold have gone into the coffers of the magnates and the racketeers, and millions of mouths are now empty.

America is not only an example, the whole world is not only suffering from this *debacle*, but is practising the same methods, and will, unless something is done, suffer the same fate. The pace in the competitive race is set by the fastest runner, and all the nations are following along the course. The only word which applies to the American credit system is dumping in the home market. It has become a universal phenomenon of home and foreign, national and international trade. With the present glut of wheat, wool, rubber, cotton, motor cars, trinkets, and the million products of mechanised production catering for an abnormally depressed and decreasing market, there is no alternative. For many years it was convenient for America and Germany to dump their surplus products upon the world ; now it is a necessity for all the nations to do the same. Russia has set the example with her presumably slave-grown wheat. Germany is cutting down prices of labour and commodities alike in order to ensure successful competition in a phantom world market.

The British Empire was impoverished by the war ; America has become bankrupt by her dumping of the home market and has impoverished the world ; Russia's avowed intention is to spread further ruin with her wheat and other commodities ; Germany is about to deal another devastating blow to her own and world prosperity.

All this can be traced to the false economic principle of buying in the cheapest market, of spending the least possible amount of money on articles of every-day consumption, regardless of their origin. An ever decreasing expenditure on individual needs must result in an equivalent depletion of income. The curse of the competitive system is most severely felt when it affects wages, and already the universal cry is "down with the cost of labour."

The remedy is obvious. We need a new economic law. The best investment for savings is to put them into circulation. For the individual, the shopkeeper, the whole-

saler, the distributor, the manufacturer to adopt a liberal policy in all his cash dealings, so that as was the case before the crash in the States, "sales will ripple out in all directions." The capital inflation of business must be abolished and the exploitation of the public by overcapitalisation be prohibited. If there is a rise in the value of industrial securities, close the stock exchange when the boom comes in the interests of the public; not, as is now done, at the time of slump in the interests of capital—and so on.

A. F. SWAINE.

London, S.W. 1, November 24th.

THE INFERIORITY COMPLEX.

SIR,—It is to be trusted that your very trenchant and informative remarks will help to resuscitate the old spirit of trade arrogance displayed by all our old engineers. But I fear the bankers' nominees will not be able to understand you.

The inferiority complex of our gas plant engineers must either be complete or the preference for "insinuating foreigners" be supreme, when one sees enormous erections of gas-making plants of German design going up all over London. Do our designers not know enough about the retorting of coal to satisfy the statutory authorities? Even if the efficiency were a little less and the cost a little more, it seems better for the money to be paid to our own people, especially as there is heavy displacement of labour. Freakish gasometers of foreign design are also springing up to uglify the horizon.

I speak of the gas industry, as these erections obtrude themselves on our observation, and must make the workers wonder at the mentality of the orderers thereof. But the engineering trade generally is paying far too heavy royalties on foreign patents of all kinds, and the sooner we resume leadership the better for our trade and self-respect. May your remark sink deeply in. W. W. S.

London, November 25th.

Wireless on Trains.

THE first train to be equipped throughout for the reception of wireless broadcast programmes left King's Cross station for a trip to Hertford at 3 p.m. on Thursday, November 20th, and returned to King's Cross at 4.37 p.m. The object of the trip was to give a demonstration of the wireless service which is being provided by the London and North-Eastern Railway on the express train which leaves King's Cross at 10.10 a.m. for Leeds and returns the same afternoon from Leeds at 5.30 p.m. Both the dining car saloons and the adjacent passenger compartments have been specially wired and fitted with sockets into which headphones can be plugged, so that whilst reclining in their seats passengers can listen to the B.B.C. National programme broadcast from Daventry. On payment of one shilling passengers are provided with a pair of headphones, which are of an easy fitting pattern and exceptionally light. The apparatus has been installed under the direction of Mr. H. N. Gresley, the chief mechanical engineer, and Mr. Leslie McMichael, whose firm has been responsible for the manufacture of the equipment.

At one end of the train in the guard's brake van a standard McMichael three-valve all-mains receiving set has been installed and is supplied with energy from a rotary converter coupled to the train-lighting set, so that no additional batteries are required. The receiver is coupled to an aerial consisting of a single wire approximately 30ft. long stretched along the roof of the guard's brake van outside the train. The rotary converter is connected to the 24-volt train-lighting set and supplies the receiver with the H.T. and L.T. and grid bias voltages, the necessary rectifiers being housed in the receiver itself. The receiver consists of a screen grid H.F. valve, followed by a detector and one stage of L.F. amplification, consisting of an A.C. mains Pentode valve. In order to reduce vibration, the receiver is housed in a thickly padded wooden lock-up case, and access to the set is obtained by a drop front. Under normal working conditions, however, it will only be necessary for the railway man responsible for the operation of the apparatus to close a single switch, which starts up the rotary converter. The act of closing this switch alone is sufficient to start the set, which has been previously tuned to the required wave length. The receiver is calibrated in wave lengths, and a moving pointer, controlled by a single knob, moves over an illuminated scale and allows any wave length between 200 and 2000 m. to be selected. Once the tuner has been set vibration will not interfere with the chosen wave length, and inspection should not be necessary for long periods. A pilot light, fitted over the motor generator, shows at a glance whether the set is running or not.

Apparently, the new development is the outcome of experiments made in the past. As long ago as May 27th, 1924, in co-operation with the Radio Society of Great Britain, the L.N.E.R. carried out a series of wireless tests in order to ascertain the loss of signal strength in reception on trains in motion, the effect of passing through iron ore bearing districts, the effect of passing through tunnels and the practicability of wireless telegraphy. For these tests a specially equipped wireless van was attached to the 7.30 East Coast express from King's Cross to Newcastle, when transmissions from the train were intercepted over a distance of more than 200 miles. Again, in 1925, through co-operation with the British Broadcasting Company, on the occasion of the celebration of the Railway Centenary, the L.N.E.R. arranged for a wireless relay to take place from the footplate of an engine drawing a sleeping-car express on its journey between Potter's Bar and Hitchin, including conversations and the incidental noises such as those arising from the taking up of water and the reception of mails. On that occasion a special broadcasting van was attached to the front of the 8.25 p.m. express from King's Cross and the actual broadcast took place between 8.53 and 9.6 p.m. This was the first occasion on which speech and sounds of an engine in motion were broadcast from an express train *en route*. A microphone was installed on the locomotive tender and was connected by a cable to the wireless van, which was equipped with three outside aerial wires. Two of the railway telegraph wires adjacent to the track were insulated over a distance of some miles, and at Hatfield Station a receiving set was connected to these wires. From this point the relay was carried by land line to Savoy-hill.

With the introduction of the non-stop run of the "Flying Scotsman" between King's Cross and Edinburgh, arrangements were made in June temporarily to place two portable receiving sets in the restaurant cars of the expresses, and by co-operation with McMichael, Ltd., the result of the Derby were stamped on cards and handed round to the passengers. This arrangement is now an annual event, and it has been carried out three years in succession, whilst on one occasion wireless pictures of the race were also received subsequent to the running commentary of the Derby.

A demonstration contrasting the comfort by air and rail was made in 1928, when passengers of an Imperial Airways liner travelled on the "Flying Scotsman," whilst certain passengers from the "Flying Scotsman" travelled in the air liner. McMichael portable receiving sets were carried on the non-stop express to enable the rail travellers to keep in touch with the pilot of the air liner. By means of wireless the train passengers were advised of the exact position of the aeroplane from point to point, and received greetings from the air as the two units of transport passed across the Tweed together at Berwick. On May 23rd, 1928, successful reception of a special programme from Melbourne, Australia, was achieved by Mr. C. G. Allen, of McMichael, Ltd., on a short-wave length for the benefit of a party of Australian scouts who were travelling to Edinburgh, and this is said to constitute a world record for train reception. The possibilities of a loud-speaker gramophone installtion in a Pullman car was recently tested by the L.N.E.R., but it was obvious that this type of entertainment would not meet with the approval of train travellers.

WELDING WITH COVERED ELECTRODES.

IN a pamphlet published by VDI-Verlag, Dr.-Ing. Baumgärtel states that it has been ascertained that the diminution of the strength, and especially of the elongation, of electric arc welds made with bare electrodes is chiefly due to the material absorbing oxygen and nitrogen from the air during the welding process. To prevent this, dipped or covered electrodes are used. Tests carried out by Kantner have shown that the use of dipped electrodes has no material influence on the tensile properties of welds. The present treatise clears up the problem of the influence of coverings. A great number of commercial steel sheets of 6 mm., 12 mm., and 20 mm.—approximately ¼in., ½in. and ¾in.—thickness were welded together, using four different asbestos-covered electrodes, and employing D.C. as well as A.C. To obtain a basis of comparison, welds were made also with bare and dipped electrodes. Depending on the thickness of the sheets, the seams were prepared for plain, or for single, or double-Vee butt welds.

With the welded samples thus obtained, tensile, folding and notch-impact tests were carried out. Supplementary ball-pressure tests in the weld, in the transition zone, and in the sheet proper were also made. Furthermore, a great number of metallurigcal and X-ray examinations were made, and the characteristic results recorded in numerous macro and micrographs. For each test the welding current and welding voltages were measured, the consumption and waste of electrodes calculated and the welding depth ascertained.

The results show that the tensile strength and the elongation of the samples properly welded with the aid of covered electrodes are considerably increased, as compared with the samples welded with bare electrodes. This is confirmed by the folding tests carried out, in which much larger bending angles were obtained. A fair number of samples was even bent through 180 deg. without showing any fracture. The results of the notch-impact tests vary greatly, as here the thermal influence of the welding process becomes particularly conspicuous. The impact strength varies with the position of the notch in a zone which has been heated to a greater or lesser degree. Local structural irregularities—embedded particles of slag—often influence the result.

The Brinell hardness does not differ greatly from that found on the welds made with bare electrodes, but is always greater than that of the non-welded material.

X-ray and metallurgical examinations reveal a much closer grained structure in the welds made with covered electrodes than is possessed by welds made with bare electrodes.

Summing up, it can be said that, given good work and the right composition of the covering, it is possible to obtain improved tensile properties in welds by the use of covered electrodes.

THE ASSOCIATION OF CONSULTING ENGINEERS.—The twenty-first anniversary dinner of the Association of Consulting Engineers was held at the St. Stephen's Club, Westminster, on the evening of Wednesday last, November 26th. These gatherings are always most enjoyable. There is an atmosphere of good-fellowship about them that one does not seem to meet anywhere else. Everyone seems to know everyone else and all appear to be in holiday mood. The Association is always most happy in its choice of speakers, and on Wednesday last the speeches were all of them excellent. The toast of "The Houses of Parliament" was proposed by Mr. E. A. Sandford Fawcett and replied to in happy vein by Lord Hanworth for the Upper House and by Mr. E. T. Campbell, the lately elected Member for Bromley, for the House of Commons. "The Engineering Industry," proposed by Sir John Brooke, was responded to by Mr. D. A. Bremner. Then, in a charmingly witty speech, Mr. Justice McCardie gave the toast of the evening—that of "The Association." The learned judge always delights his audience—at any rate when he is making an after-dinner speech—and he certainly did so on Wednesday. Mr. A. H. Dykes—the Chairman of the Committee of the Association—in his reply was equally entertaining. Altogether it was a most successful evening.

Battersea Power Station and Sulphur.

IN our issue of November 29th, 1929, we dealt with an Interim Report on "Treatment of Sulphur Fumes in Connection with the Working of the Proposed Electric Power Station of the London Power Company at Battersea," which had been presented by the advisers to the company.

A second report, which bears the date of June 2nd last, and which is signed by Dr. E. Ardern, Dr. F. G. Donnan, Mr. J. Arthur Reavell, and Dr. R. V. Wheeler, has just been issued by the Ministry of Transport as a White Paper—Cmd. 3714—which also contains a Report on the subject made by the Committee presided over by the Government Chemist. Both these documents are reproduced below. They are prefaced in the White Paper by the following note:—

In authorising the publication of these Reports the Minister of Transport has ascertained from the Committee presided over by the Government Chemist—

(1) That the Committee are satisfied from the experiments made at the Grove-road station of the London Power Company that it is practicable to install, in connection with the first section of the Battersea station, a plant which will reduce the emission of sulphur fumes to a negligible quantity;

(2) that the Committee are satisfied that, if such a plant is installed at Battersea, it will be practicable to treat the liquid effluent so that it may be such as can be admitted into the river.

The Committee point out that it would be for the Port of London Authority, as the body responsible for preventing pollution, to see that the necessary measures are taken.

Treatment of Sulphur Fumes in Connection with the Working of the Proposed Electric Power Station of the London Power Company at Battersea.

SECOND REPORT.

This Report deals with the investigations that have been carried out by the London Power Company at the Grove-road Power Station since the date of the issue by the Ministry of Transport of the White Paper—Cmd. 3442—entitled "Treatment of Sulphur Fumes in Connection with the Working of the Proposed Electric Power Station of the London Power Company at Battersea."

The first series of supplementary experiments were conducted on the original experimental plant—described

Table of Results.

	Full load.	Half load.	Half load and alkali.
Coal.			
Lb. per hour	8,630	4,690	4,330
Carbon, per cent.	63·2	65·9	65·8
Sulphur, per cent.	0·90	0·89	0·84
Gas.			
Cu. ft. per ton coal at 60 deg. Fah.	375,000	490,000	485,000
Average CO_2 content of inlet gas, per cent.	11·3	8·9	9·1
Temperature of inlet gas, deg. Fah.	229	231	225
Temperature of outlet gas, deg. Fah.	75	83	96
Cu. ft. per hour at average temperature of 152 deg. Fah., 157 deg. Fah., and 160 deg. Fah. respectively	1,690,400	1,206,400	1,107,600
Inlet gas, SO_2, m.gms. per litre N.T.P.	0·90	0·57	0·93
Inlet gas, SO_2, ditto ditto	0·90	0·68	0·49
Total S, ditto ditto	0·81	0·56	0·665
Total S grains per cu. ft., do.	0·354	0·245	0·29
Outlet gas, SO_2 m.gms. per litre, ditto	0·43	0·13	0·019
Outlet gas, SO_2 ditto ditto	0·59	0·31	0·026
Total S, ditto ditto	0·451	0·185	0·02
Total S grains per cu. ft. do.	0·197	0·081	0·009
Per cent. removed SO_2	52	77	98
SO_2	35	54	96
Total S	44	67	97
Water and Effluent.			
Tons per ton of coal	27	50	13½ plus* alkali
Gallons per hour	23,100	23,100	5,845
SO_2, grains per gallon	13·4	6·0	28·4
SO_2, ditto	8·0	14·3	42·1
Total S, ditto	9·9	8·7	31·0
(or parts per 100,000)	14·1	12·4	44·3
Total Fe, ditto	2·5	1·7	8·9
(or parts per 100,000)	3·6	2·4	12·7

* The smaller quantity of water is explained by the use of increased contact surface.

Sulphur Balance Sheet.	lb.	lb.	lb.
Coal S. per hour	77·6	41·7	36·4
Inlet gas, ditto	73·0	36·0	38·8
Outlet gas, ditto	41·2	11·9	1·2
Effluent, ditto	32·6	28·7	39·2
Ash, ditto	2·15	0·7	0·7
Column 3, in addition to the water used, alkali was re-circulated at the rate of 300 gallons per hour and contained:—S, grains per gallon 305			13·1

These figures are included in the above balance sheet.

Time of Passage of Gas in Free Space in Seconds.

Horizontal—1st Section, 11ft.	2	3	3
Horizontal—2nd Section, 23ft.	4	6	6
Vertical (effective), 15ft.	2½	4	4

in the foregoing White Paper—and were directed to ascertaining the value of iron as a catalyst and the degree of sulphur elimination obtainable with or without iron in the circuit of the gases. Inasmuch as the later experiments on the large-scale plant—referred to below—confirmed the results, no further reference to these supplementary experiments is necessary.

This large-scale plant—working in connection with boilers

in daily operation—was not erected as a result of the experiments described in the White Paper, but had been designed and constructed independently before the former results were known. Certain modifications were subsequently introduced. For example, in order to avoid any chance effects due to iron, all iron was excluded from the surface material by coating it with cement.

Experiments were first carried out with the plant coated in this manner ,i.e., with the total elimination of any iron surface.

Prior to entering the gas-washing plant, the flue gases were passed through a grit arrester of the cyclone type. Afterwards, they passed through three horizontal channels arranged in parallel, the length of each channel being 34ft. by 9ft. 9in. high by 2ft. 9in. wide—see Fig. 1*. Subsequently, the gases were collected and passed through a vertical tower 12ft. by 7ft. 6in. in cross section and 34ft. high. This vertical tower contained a filling of pottery rings, the depth of which was 4ft., this material being sprayed with water, whilst the gas in its passage through the horizontal chambers was also well sprayed with water.

Operating in this manner the percentage elimination of sulphur from the gases was about 20 at varying boiler loads, the quantities of water used ranging from 12 to 40 tons per ton of coal burnt.

To test the effect of iron, the first 11ft. of each of the horizontal chambers was then filled with corrugated iron sheets spaced 1in. apart and extending from the floor to the ceiling. Sprays were arranged in the ceiling so as to deliver water over the surface of the sheets.

When using iron sheets, the remaining part of the horizontal chambers was sprayed with water as in the previously mentioned case, and the pottery rings in the tower were flushed with water as before.

The results of the experiments carried out in this manner are given in the table of results. From these it will be seen that with full boiler load the elimination increased to 44 per cent.—instead of 20 per cent. without iron—and that when the boiler was working on half-load an elimination of 67 per cent. was obtained.

It will also be seen from the table that when the boiler was operated at half-load and a solution of carbonate of soda was circulated through the vertical tower, an elimination of 97 per cent. was obtained.

It may be further mentioned that when the boiler was operating at about one-third load, the elimination of sulphur reached a figure of 75 per cent. without the use of anything except water in the vertical tower.

We feel convinced that with an ample capacity in the gas-washing plant†—as will be the case at Battersea—affording thus a sufficient time of contact, and with iron as a catlyst, the elimination of sulphur from the gases, without any use of soda or other alkali, should reach 80 to 85 per cent. at least. We think, therefore, that relatively little akali will be required in actual practice to complete the total elimination of the sulphur, although provision has been made in the design of the Battersea plant for such treatment.

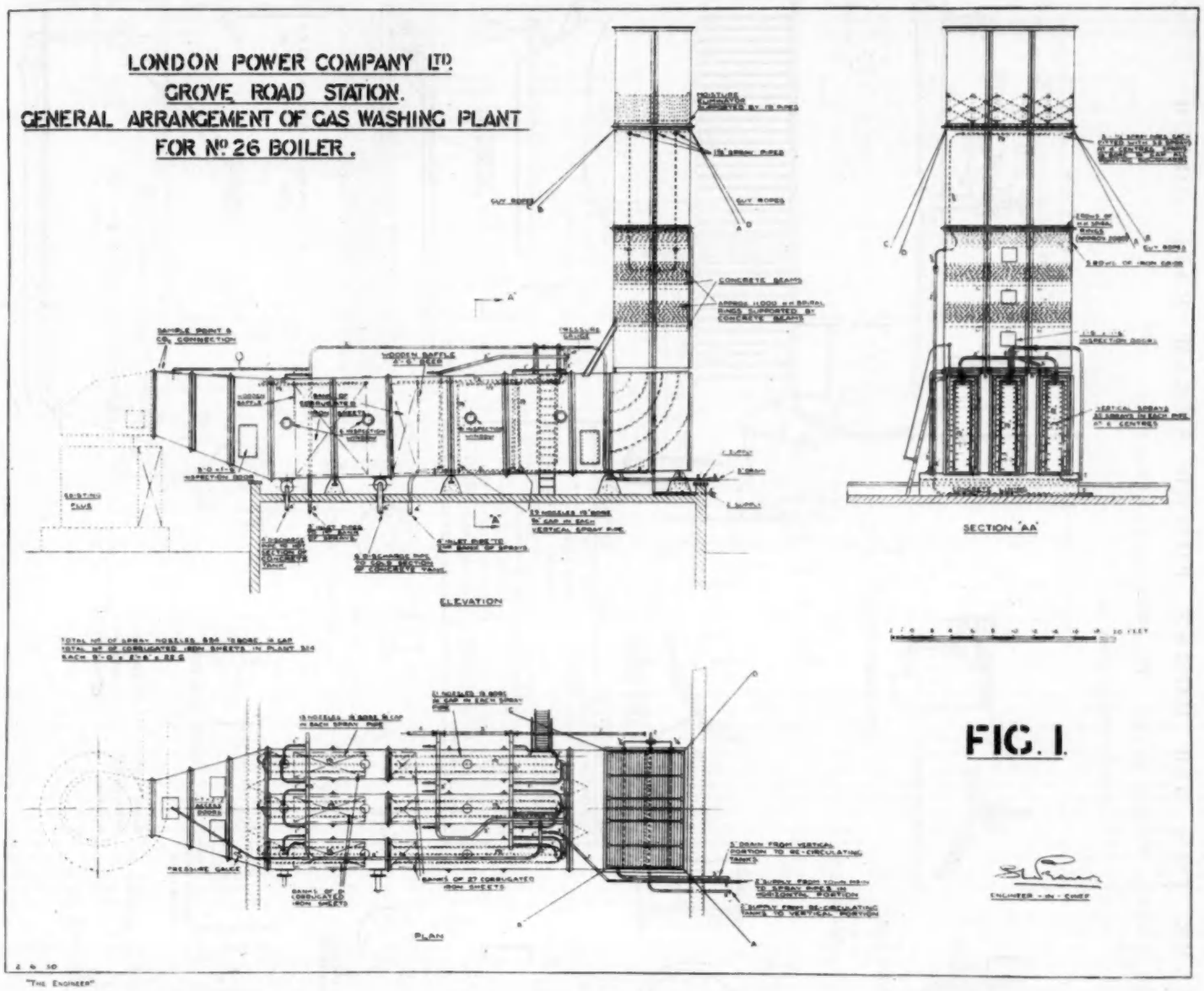
A point of importance concerns the composition of the effluent. It will be seen from the figures given in the table that there remains in the effluent liquid a certain proportion of sulphite which it will be necessary to convert into sulphate. Since in the working plant at Battersea it will be necessary to have settling tanks to remove dust and grit collected in the effluent, there will be opportunity for the complete conversion of sulphite to sulphate, and precipitation of the iron as hydrate.

On the question of cost, we have received from Dr. Pearce, the engineer-in-chief to the London Power Company, Ltd., his estimates of the capital and operating costs incidental to the application to the Battersea Power Station of the proposed gas-washing plant and system.

On these estimates we consider the system to be a commercially practicable one in its application to the Battersea station.

We have again to express our indebtedness to the technical staff of the London Power Company, Ltd., for their valuable co-operation in this further investigation, and in particular to Mr. Hewson and his colleagues for the admirable analytical control of the experimental plant.

(Sgd.) E. Ardern, D.Sc., F.I.C.
F. G. Donnan, D.Sc., F.R.S.
J. Arthur Reavell, M.I.M.E., M.I. Chem. E.
June 2nd, 1930. R. V. Wheeler, D.Sc., F.I.C.



FACSIMILE REPRODUCTION FROM REPORT—REDUCED

Report of the Committee Presided Over by the Government Chemist.

Government Laboratory,
Clement's Inn Passage, Strand, W.C. 2,
July 22nd, 1930.

Sir,—We have now read the Second Report of the Advisers to the London Power Company. In addition, a representative of the Government Laboratory on April 8th, 1930, visited the Grove-road installation while an experiment was in progress and made some chemical determinations. Further, on June 30th, 1930, we visited the plant at Grove-road and had a discussion on the Second Report with Dr. Pearce, his advisers and staff.

We are satisfied in the first place that the elimination of sulphur gases at the exit in these experiments was nearly complete, and this was confirmed by the observations of the Chemist from the Government Laboratory mentioned above, who at the same time found that about half the burden of removal was borne by the sodium carbonate wash. The protecting lining was not contributing to the neutralisation of acid, and was in fair condition, a matter of less moment now when we are informed that acid-proof bricks are to be used at Battersea. We were informed that the excessive cost of soda ash for neutralising residual sulphur gases will not be incurred, as it is proposed to use milk of lime, which is considerably cheaper, and that the sludge of dust, lime salts, including calcium sulphite and iron oxides, would be removed from settling tanks and not discharged into the Thames.

We note that it is now recognised that the conversion to sulphate obtained in the First Report was due to the catalytic action of iron, but we are not clear that any marked advance in the process as such has been made beyond the results reported there. In the present experiments the degree of catalytic conversion of sulphurous to sulphuric acid is comparatively small, the elimination of the sulphur acids being mostly by solution or neutralisation by alkali.

Generally, we may say that the company has achieved the object of eliminating sulphur gases from the flue gases on a fairly large scale, but we think the process used is capable of improvement in several directions, including cost.

We should be glad to see the results of any further experiments, especially any dealing with the oxidation of sulphite to sulphate before effluent containing it goes into the Thames, whether sodium carbonate be used or, as is indicated in the Report, and as we were definitely informed, the use of a cheaper alkali is contemplated. The nature of the effluent which may be discharged is a matter for the Port of London Authority.

We recommend that the Ministry be given access to the records of the Chemist supervising the working of the plant.—We are, Sir, Your obedient Servants,

(Sgd.) Robert Robertson, Chairman.
C. H. Lander.
T. Lewis Bailey.
J. Macintyre.

The Secretary, Ministry of Transport,
46, Whitehall-gardens, S.W. 1.

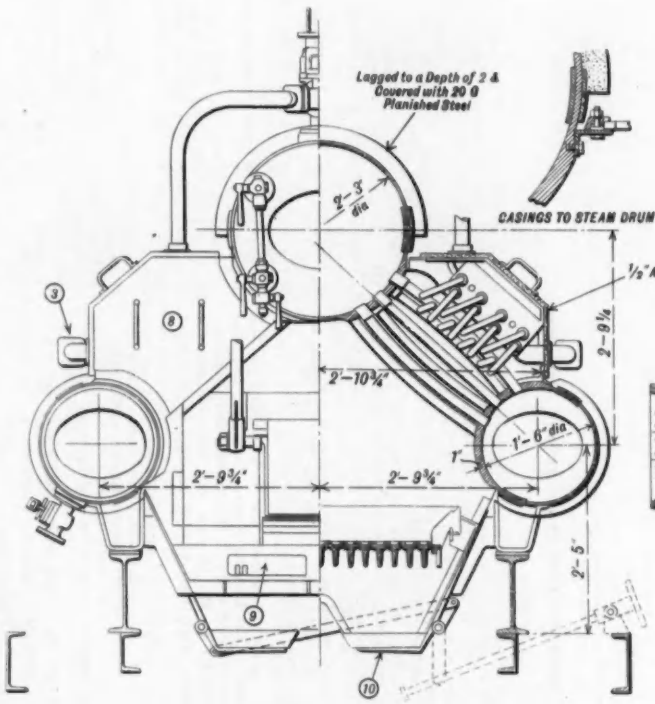
* Reproduced in facsimile ,to a smaller scale, herewith.

† Dr. Pearce's gas-washing plant was illustrated and described in our issue of October 10th, 1930.

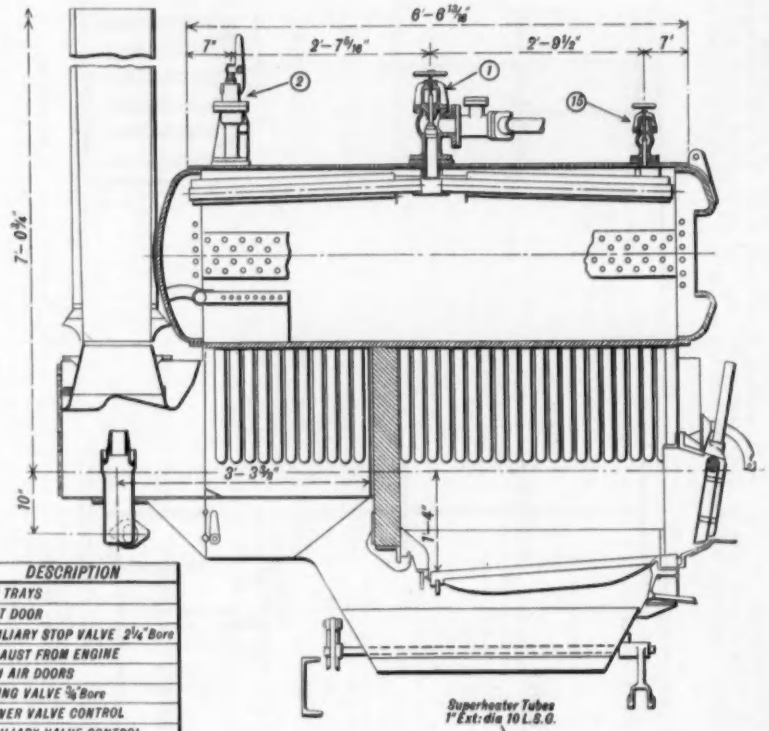
WATER-TUBE BOILER FOR 200 HORSE-POWER STEAM RAIL COACH

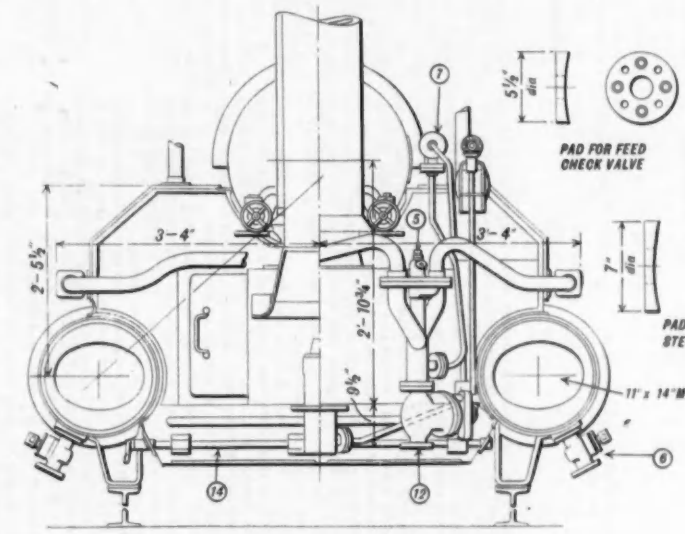
THE SENTINEL WAGGON WORKS, LTD., SHREWSBURY, ENGINEERS

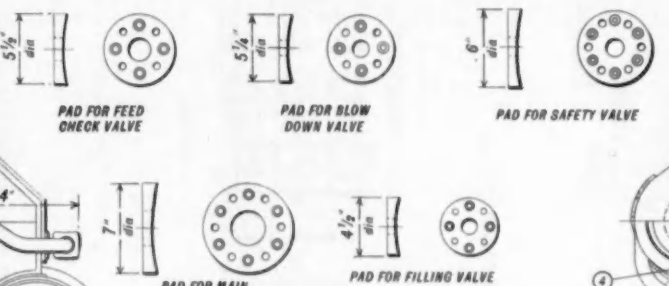
(For description see opposite page.)



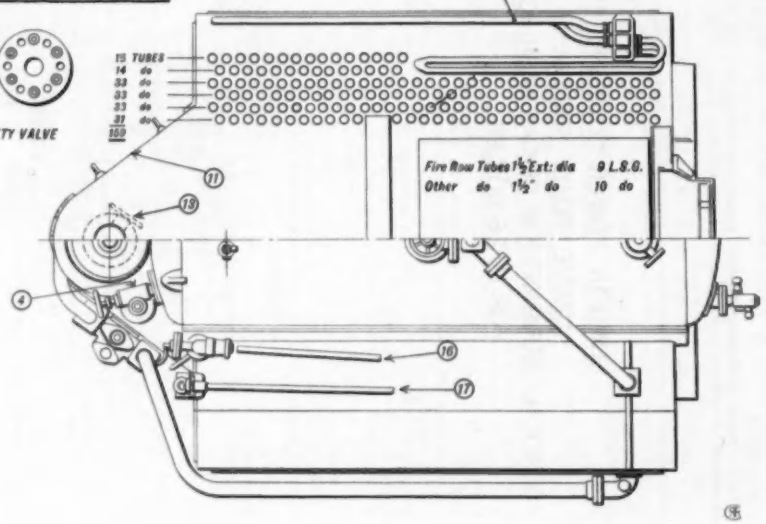
No.	DESCRIPTION	No.	DESCRIPTION
1	MAIN STOP VALVE 2¼"Bore	10	ASH TRAYS
2	SAFETY VALVE (Double) 1½"Bore	11	SOOT DOOR
3	THERMOMETER POCKETS	12	AUXILIARY STOP VALVE 2¼"Bore
4	FEED CHECK VALVES 1¼"Bore	13	EXHAUST FROM ENGINE
5	SUPERHEATER SAFETY VALVE 1⅛"Bore	14	MAIN AIR DOORS
6	BLOW DOWN VALVE 1"Bore	15	FILLING VALVE ⅝"Bore
7	BLOWER VALVE ½"Bore	16	BLOWER VALVE CONTROL
8	SUPERHEATER INSPECTION DOORS	17	AUXILIARY VALVE CONTROL
9	ASHPIT AIR DOORS		







Working Pressure ..... 300 lb per sq in
Heating Surface ..... 272 square feet
Grate Area ..... 12.3 square feet



"THE ENGINEER"

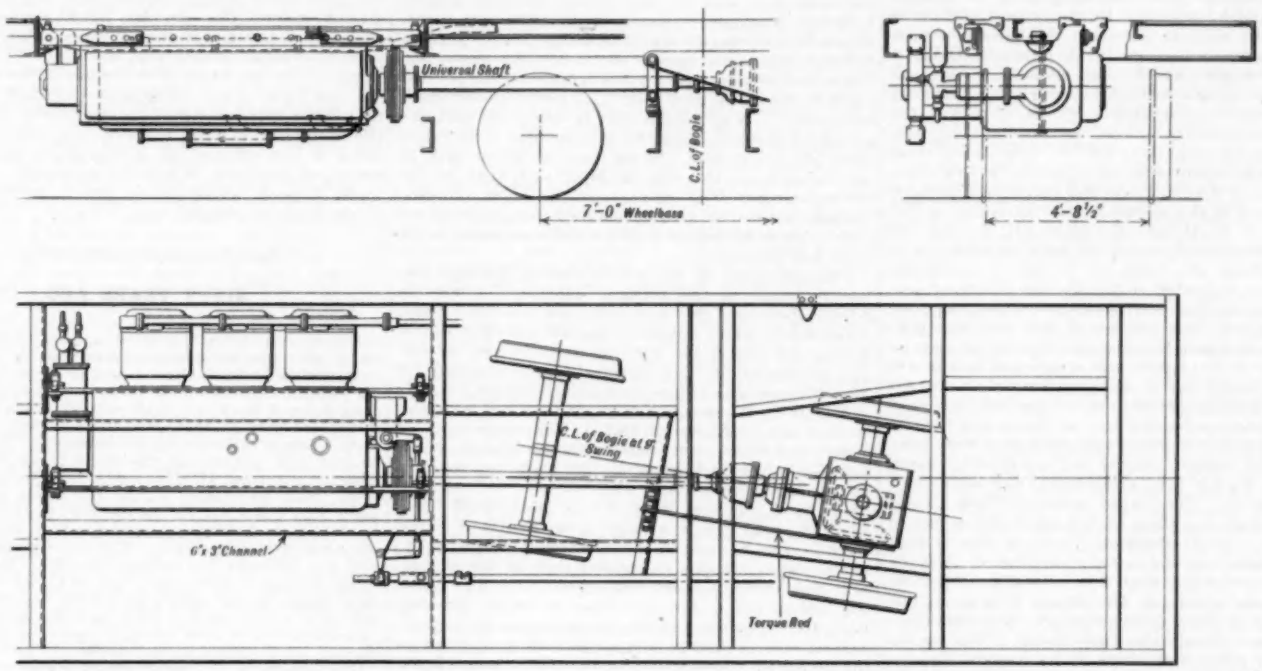
A 200 Horse-power Steam Rail Coach.

One of the latest types of steam rail coach, appropriately named the "Phenomena" (*sic*), recently made the trip from King's Cross to Cambridge and back as a sort of "house-warming," with some hundred guests on board, at the conjoint invitation of the Metropolitan-Cammell Carriage Wagon and Finance Company, Ltd., and the Sentinel Waggon Works, Ltd., of Shrewsbury. It was a most pleasant occasion, and there were among the company quite a large number of railway engineers from overseas, while our home railways were represented by their chief engineers or assistants.

We give herewith a general view of the coach and a drawing of one of the bogies, while on page 594 will be found a drawing of the boiler.

In general principle the new coach follows the ideas underlying the design of the articulated coaches for the Palestine Railways, which we described in our issue of February 8th, 1929, and those already put in service on the L.N.E. Railway. The new vehicle, however, is much more powerful and has a greater seating accommodation. The previous coaches are of 130 maximum horse-power, and are fitted with vertical, cross-tube boilers, while the new one is of 250 horse-power and has a water-tube boiler.

It will be remembered that the characteristic features of this design are that two coaches are articulated on three bogies, that all the machinery is confined to one end, and that driving stations are provided at each end.

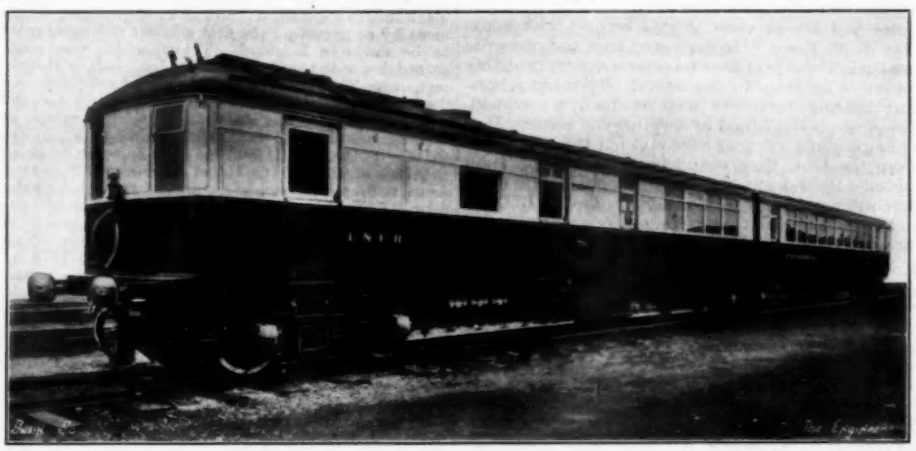


Arrangement of Engine and Bogie

So far the new vehicle does not depart from its predecessors, but it is equipped with two separate engines, each of which drives one of the axles of two bogies, an obvious necessity to absorb so much power. The arrangement is such that, supposing the coach is running with the machinery in front, the leading axle of the front bogie is driven by one of the engines, while the trailing axle of the articulating bogie, which is of the Gresley patented type, is driven by the other engine. There is no connection between the two drives.

The engines themselves are of the standard Sentinel type with six single-acting cylinders, 6in. in diameter by 7in. stroke. This engine was fully described and illustrated in The Engineer of May 18th, 1928, so it is not necessary to enlarge upon its construction here. It is sufficient to say that the cylinder heads, in which the valve chests and ports are incorporated, are detachable. The valves are of the poppet type, and are operated by cam shafts. By sliding the cam shafts longitudinally the cut-off can be varied in three steps of 75, 45, and 27 per cent. in either direction of rotation. Cams are also provided, in an intermediate position, which hold up both the admission and exhaust valves, so that steam can be blown straight through the engine for warming up purposes. There is a feed pump on the end of the crank shaft of each engine, and they are supplemented by two injectors on the boiler for use when the vehicle is standing. The normal rating of each engine is 100 horse-power, but it can be worked up to 125 horse-power, and runs at 500 revolutions per minute when the coach is making from 30 to 38 miles per hour, according to the ratio of the gearing. It will, however, run quite comfortably at speeds of about 1000 revolutions per minute.

The two engines are slung beneath the main framing of the motor coach, and are arranged with the cylinders looking transversely, so that the crank shafts are longitudinal. The engines face in opposite directions. At the driving end of the shaft there is a Hardy-fabric flexible coupling for connection with a propeller shaft, which is approximately on the centre line of the coach, as shown in the drawing. This propeller shaft extends to just beyond the pivot of the bogie, where it is fitted with a Spicer universal joint on a splined shaft to take up longitudinal movement. This joint is on a short shaft extending from the gear case mounted on the driving axle. Within the gear case there is a 1 to 1 mitre gear, which drives a lay shaft above the main axle. This shaft, in turn, drives the main axle through spur gearing, which is so arranged that the ratio can be easily altered by changing the wheels to adapt the machine to local running conditions. The torque is taken by a flat stay of spring steel bolted to the side of the case and pinned at its outer end to a swing link mounted on the cross bar of the bogie. The whole of the gearing is enclosed in an oil-tight casing, and arrangements are made to flood the top bearings with the oil lifted by the wheels, which is caught by deflectors and lead over the bearings. The lay shafts are carried in Timken bearings, and the whole of the gearing is lightly loaded—a fact which we verified by feeling the warmth of the gear cases after a considerable run at a speed ranging round 60 miles per hour. None of the gear was as warm as the plates from which the company had taken an excellent luncheon in Cambridge in celebration of the occasion.



200 H.P. Articulated Steam Rail Coach

However, to return to the machine itself, the boiler is, perhaps, one of the outstanding features, as it is of the true water-tube type, patented by Mr. Woolnough. The working pressure is 300 lb. per square inch, and although the steam is superheated, the rise of temperature is not carried so far that unusual precautions need be taken in the lubrication of the cylinders of the engines.

As will be seen from the drawing on page 594, the boiler is a compromise between the original Yarrow and Thornycroft types, in that it has two water drums and one steam drum, connected together by banks of slightly bent water tubes. No attempt is made to determine definitely the circulation of the water through these tubes, except that the gases of combustion pass through each bank of tubes in a double bend, so that the last row of tubes bathed by the gases must obviously be less fiercely heated than those of the first rows, and, consequently, may act as downcomers, although we doubt whether, in actual fact, such a precise regime exists. That there is good circulation is obvious from the steaming of the boiler, but it is probably fortuitous.

The double passage of the gases through the tubes is effected by building a wall right across the boiler half-way along its length, as plainly shown in the drawing. This wall terminates the grate and the combustion chamber and drives the gases outwards through the water tubes, whence, passing the tubes they flow longitudinally through the superheater and return through the water tubes into the chamber behind the brick wall, which acts as a smoke-box, although it is still within the limits of the boiler proper. The smoke stack is connected with the end of this chamber.

The three drums are all of generous proportions, so that a man can get inside—the steam drum is 2ft. 3in. in diameter—and any one of the tubes can be drawn out into the top drum without disturbing its neighbours. The feed water is introduced at the cool end of the boiler, so that any sediment may be deposited as far away from the fire as is possible. The heating surface of the boiler is 272 square feet and the grate area 12·3 square feet. It measures, roughly speaking, 7ft. 6in. square, yet it is capable of providing steam for 200 horse-power.

The length of the coach over the body is 106ft., and it is capable of seating 122 passengers. When full it weighs 67¼ tons. The wheel base of the two driving bogies is 7ft., while that of the third bogie is 6ft. 6in. Standard buffing gear is provided at each end, and the coach is electrically-lit by a little turbo-dynamo set.

Royal Metal Trades' Pension and Benevolent Society.—Sir Gerald Chadwyck-Healey, chairman of Morgan Brothers (Publishers), Ltd., proprietors of The Engineer and the *Ironmonger*, was in the chair at the eighty-second annual festival dinner of the Royal Metal Trades' Pension and Benevolent Society on November 25th. The dinner was held at the Hall of the Worshipful Company of Ironmongers, whose Senior Warden, Mr. G. G. Harris, was present. In proposing the toast of "The Society," the Chairman launched an appeal for further subscriptions to the funds, and said that no suggestion of charity should attach to the Society's work. Its pensions and grants were given in friendly recognition of good service rendered, and even if parts of the trade were not exactly basking in the rays of prosperity, the fact was no excuse for deafness to the demands of such a cause. The Society stood for the human touch—a factor in which he himself had great faith. More money was badly needed for the Society's benevolent work; but the anchor of Good Hope swung at their cable, and he felt confident the future would not disappoint them. Sir Ernest Petter, M.I. Mech. E., chairman of Petters, Ltd., spoke in support. Of the 30,000 firms in this country eligible to subscribe to the fund, only 5000 at the outside were regular contributors, he said. He pledged himself to obtain seven new subscribers in the coming year, and hoped that all others present would follow this example. Major O'Brien, of the Society's Board of Management, said that although the Chairman had modestly referred to himself as "a ship that passed in the night," and said that the real work of the Society was done by other hands, he would like to assure Sir Gerald that he had at any rate passed under full sail. The year's appeal had been most successful. It was announced that the appeal had resulted in subscriptions totalling £1786, a figure well in advance of last year's.

Institution of Mechanical Engineers.

HEAT TRANSFER FROM TUBE TO WATER.

THE paper presented last Friday evening by Messrs. Eagle and Ferguson before the Institution of Mechanical Engineers, in spite of its "difficult" nature and its largely mathematical basis, attracted a good audience and elicited a satisfactorily lively discussion. It dealt with the transfer of heat from tubes to water flowing within them and divided itself into two natural parts. In the earlier portion an account was given of some experimental work undertaken by the authors, including a criticism of previous experimental methods, a description of the authors' improved apparatus, and the tabulation of sample results obtained by them. In the second portion of the paper the authors discussed the theory of heat flow and advanced a modified form of Osborne Reynolds' formula, which, they claimed, fitted their experimental results with close accuracy. This part concluded with the establishment of values of the constants required to make the authors' formulæ applicable in practical design work. The first portion of the paper is reprinted in full elsewhere in this issue.

The origin of Messrs. Eagle and Ferguson's research was explained in the course of the discussion by Dr. Stoney, Mr. I. V. Robinson and Mr. H. L. Guy, all of whom were closely associated with its inception or conduct. Some six years or so ago a condenser manufacturer suggested to the British Electrical and Allied Industries Research Association that the time was ripe for a thorough review of our knowledge concerning the factors governing the transfer of heat in condensers. A committee was appointed, and it was decided to carry out a wide investigation of heat transfer in general, not only in condensers, but in all other apparatus such as air and oil coolers and heaters of various kinds, involving the passage of heat from one fluid to another across an intervening metal boundary. So far only a beginning has been made with the work. The paper presented last Friday deals only with a portion of the condenser aspect of the subject. In a condenser there is a flow of heat from the steam into the metal of the tubes. A study of this portion of the heat flow presents many difficult problems which, in Dr. Stoney's opinion, will probably never be completely solved. Next there is a flow of heat through the tube metal. This aspect presents no great difficulties in its study. Finally, there is a flow of heat from the tube metal into the cooling fluid. It was this aspect, and this one alone, that Messrs. Eagle and Ferguson discussed in their paper.

The results and equations presented by the authors are therefore strictly limited in their application. They are confined not only to the phenomena occurring on one side of a heat transferring tube, but are restricted to the case in which the heat-receiving fluid is water. More accurately perhaps they are restricted to the case in which that fluid is one for which the quantity referred to as σ ranges in value from about 3 to about 15. This quantity, of which much was heard during the discussion, is a compound factor composed of the viscosity of the fluid receiving the heat multiplied by its specific heat and divided by its thermal conductivity. In the authors' experiments the value of σ ranged from 2·99 when the water flowing through the tubes was at 140 deg. Fah. to 10·6, its value when the water was at 40 deg. Fah. For air and other gases, σ may be less than unity. For oil it may be as high as 2000. Dr. Stoney emphasised the fact that the authors' equations and constants were not applicable outside the range of σ covered by the experiments and suggested that experiments of a similar nature with oil as the heat-receiving fluid would yield very valuable information. In the paper itself the authors show how the formula for the coefficient of heat transfer might be modified to extend it to low values of σ. In his reply to the discussion, Mr. Eagle admitted that the formula failed for values of σ above about 40, and that to make it applicable to high values it might have a third term $c\,(\sigma-15)^2$ added to it. Mr. Robinson, a member of the Committee in charge of the research, indicated that before it was concluded it would be extended to cover high values of σ, such as those shown by oil.

The paper appears to throw considerable doubt on the correctness of the Osborne Reynolds' theory of heat flow. Professor F. C. Lea, however, defended that theory. Because the authors' coefficients would not fit in with Reynolds' theory was no reason, Professor Lea said, for holding that Reynolds' theory was incorrect. In actual fact, no agreement was to be expected, for the authors' experimental conditions were not consistent with the conditions of Reynolds' theory. The distribution of velocity or momentum over the cross section of the water inside the pipe was parabolic, the velocity or momentum being highest at the centre and decreasing towards the tube walls. For consistency with the conditions of the Reynolds' theory, the distribution of temperature over the cross section should be similar to the distribution of velocity or momentum. In other words, the heating of the fluid should not be applied radially as in the authors' apparatus, but longitudinally. Professor Lea hastened to add that he could not propose any method whereby the requisite longitudinal heating could be carried out. Mr. Eagle did not deny that the experimental conditions were inconsistent with the Reynolds' theory conditions. To make them consistent, he pointed out, would require not only the longitudinal heating mentioned by Professor Lea, but the use of a fluid, the specific heat of which varied with distance from the centre of the flow.

Considerable attention was directed during the discussion to the authors' suggestion—really the foundation of their modified theory of heat flow—that in a stream of water flowing through a pipe there is not only a viscous-flow layer adjacent to the walls and a turbulent flow core, but an intermediate layer, a "layer of intermediate behaviour," as the authors described it. Mr. H. M. Martin would not accept the existence of this intermediate layer. Inside a pipe the boundary between the viscous film and the turbulent core was, he held, always sharply defined, however irregular it might be in time and space. He could not imagine an intermediate layer, the flow in which was partly viscous and partly turbulent. Mr. Eagle had a ready reply to this criticism. He pointed out that the words used were "a layer of intermediate behaviour." It was not a layer in which the particles possessed partially a viscous and partially a turbulent flow, but a thin film, the particles of which were at one moment in the viscous layer and next in the turbulent core. The existence of this layer of intermediate behaviour was, he claimed, not inconsistent with a sharp boundary between the accepted viscous layer and the core.

The velocities of the water flowing through the heating pipes in the authors' experiments were in general between 2ft. and 11ft. per second. Some experiments were, however, carried out with water flowing through a ¾in. tube at only 1ft. per second. The coefficient of heat transfer was determined for five different rates of heat flow into the water, namely, at 5000 B.Th.U. per square foot per hour, and multiples thereof up to 25,000 B.Th.U. The coefficient, as usual, was found to increase with the heat flow. It increased 5 per cent. when the heat flow was doubled, by the same percentage when it was trebled, and again by 5 per cent. when it was quadrupled. But when the heat flow was raised from 20,000 to 25,000 B.Th.U. the increase in the coefficient jumped up to 25 per cent. It was calculated that at the highest heat-flow rate the inner wall of the tube was above the boiling point of water—that it was at 220 deg. Fah., to be precise. At this temperature, the authors argued, there would be a rapid formation of steam at the tube wall, which would break up the viscous layer. Hence the rapid increase of the coefficient of heat transfer at this rate of flow.

One might, we suppose, take this result as an indication of the powerful blanketing effect exercised by the viscous film against the passage of the heat into the turbulent core. If the film is destroyed by being wholly or partially converted into steam, the facility with which the heat can flow from the metal of the tube into the water is, it would seem, greatly increased. No one during the discussion mentioned the bearing of this result on the theory of the steaming condenser. Mr. I. V. Robinson, however, came fairly close to it. The facts reported, he said, made one dream of what might be done if we could introduce into the cooling liquid some other liquid of low boiling point and low latent heat, which would vaporise against the tube wall and recondense in the core and in that way destroy the viscous film and eliminate its resistance to the passage of heat.

Quite a different view of this subject was taken by Dr. J. M. Long. He suggested that the observed variation in the rate of heat transfer was very probably an effect of aeration in the water. By using a horizontal heating tube the authors had, he argued, followed the best method of aerating the water. Had they employed a vertical tube and fed the water into it from the foot, they would have avoided aeration troubles. He did not state whether in his view the high coefficient of heat transfer at 25,000 B.Th.U. was to be ascribed to the presence or absence of aeration.

Much was said during the discussion regarding the apparently academical nature of the investigation. The paper, in its latter portions, was certainly mathematical. Moreover, the design of the experimental apparatus could be criticised as diverging from practical conditions. The generation of heat inside the metal of the tube by electrical means may be a convenient method of carrying out experiments on heat transfer, but, as more than one speaker emphasised, it represents a considerable departure from practical conditions in a condenser in which the heat transmitted through the tube is applied to it by steam externally or internally. Nevertheless, however academic the paper may seem, it is certain that its results have already made their influence felt in practice. Both Dr. Stoney and Mr. Guy assured the members that the data obtained during the course of the research were being used by at least one firm in the design of its products. Mr. Guy was particularly emphatic on this point. His firm, he told the meeting, had already, in the light of the research, re-examined the design of its air heaters, feed-water heaters, condensers, and so forth, and had been led to change certain of its previous views concerning the factors which should be taken into consideration. He indicated that increased efficiency would be realised and disappointment avoided by the changes that had been introduced.

There is a curious omission in the paper to which no one taking part in the discussion called attention. No mention is to be found of the metal of which the heating tube was made. We are clearly informed as to the nature of the rest of the experimental apparatus. It consisted of iron or steel piping. We are not told whether the heating tube is made of iron, brass, bronze, or copper. In actual fact, it was, so we understand, a brass tube. The question may be asked whether the omission to state the nature of the metal may be taken to imply that the coefficients of heat transfer recorded in the paper are independent of it. The answer would appear to be that they are independent of the metal of the tube. In a condenser, as has already been said, there is a transfer of heat from the steam to the tube, a transfer of heat through the tube metal and a transfer from the tube to the cooling water. The inference would seem to be that the second transfer is the only one affected by the particular metal employed in the tube. Yet, when we think of the last layer of molecules in the metal and the first layer of molecules in the water, it is difficult to believe without definite experimental proof that the coefficient of heat transfer from the one to the other is not affected by a change in the chemical nature of the layer of metallic molecules. It is certainly a point which should not be implied simply by omission to mention it.

SIXTY YEARS AGO.

THERE are very few firms existing to-day in this country which can claim an unbroken history of 150 years. One such firm is Richard Garrett and Sons, of Leiston. In our issue of December 2nd, 1870, we published an article descriptive of the firm's works and activities, from which it appears that at that date the company was within eight years of celebrating its centenary. It might be claimed with justice that the origin of the firm is even more remote than 1778, in which year Richard Garrett—the great-grandfather of the gentleman of the same name who was a partner in the firm in 1870—set up a small forge at Leiston for making sickles, edge-tools and blacksmiths' work generally. This first Garrett of Leiston was but following his father's example. He, too, was called Richard Garrett, and, first at Ufford and later at Woodbridge, in the county of Suffolk, had practised the calling of a bladesmith. From an advertisement in the *Ipswich Journal* of 1765, it would appear that this Richard Garrett of Woodbridge was much troubled by certain "bad persons in or near Sheffield," who were making sickles and hoes and stamping them with his name. The counterfeit implements were being sold wholesale in the counties of Suffolk and Norfolk at ten shillings a dozen, and retailed at eighteenpence each "to farmers and poor labourers." That was the price of the genuine Garrett articles, but in the advertisement it was contended that the counterfeit goods ought not to be sold at more than fourteen pence each, at which price they would show "profit sufficient for an honest man." Richard Garrett resolved to defeat the imposition and gave notice that in the future he would add a star to the former mark on his sickles and hoes. He was determined to protect his new mark, probably the first recorded trade mark. He announced that he was resolved that the law should determine whether other makers could use the same mark "without being punished as cheats and counterfeits." This stout defender of his rights might well be claimed to be the true founder of the business, but it is to his son, Richard II., who, as we have said, set up a similar business at Leiston in 1778, that strictly it owes its origin. Richard III. succeeded him in 1805, and a year later raised the blacksmith's shop to the rank of an engineering establishment by constructing the first efficient thrashing machine to be made in England. This machine was made in accordance with the patents of Mr. John Ball, of Hetheringsett, near Norwich. In the history of invention it is a disputed point whether the first seed drill for sowing grain by machine was made at the Garrett works, or by Messrs. Smith, of Peasenhall. Richard IV. succeeded to the business in 1836. He was one of the principal founders in 1837 of the Royal Agricultural Society. He seems to have had much of his great-grandfather's independence of spirit, for in later years, after his firm had gained nearly two hundred prizes at the Society's shows, he withdrew from participation in the engine and implement trials. The firm continued that policy. In 1870 it was the only company which refrained from the trials. A combination had been formed among other agricultural engineers which sought to secure a universal refusal to submit any machinery to be publicly tried by the Society's judges. Mutual competition and jealousy, however, led to the disruption of the combination, and Garrett's alone remained outside the prize ring.

A REPORT from Moscow states that during 1929–30, the sum of 640 million roubles was invested in electrical stations in the U.S.S.R., compared with 320 million roubles in 1926–27. In the coming year the Government proposes to appropriate another 1180 million roubles for this purpose. The report further states that the output of electrical energy has been steadily growing, reaching 8 thousand million kilowatt-hours during the past economic year, as against 6 thousand million in 1928–29. At the present time several stations are under construction. They include the Dnieprostroi, a large hydro-electric station with an ultimate capacity of 588,000 kilowatts, to be completed in 1932; the Bobrikov station—near Moscow—with a capacity of 300,000 kilowatts, to be completed in 1933; the Zuevka station—Donetz Basin—with a capacity of 250,000 kilowatts, to be completed in 1932; the Svir station, near Leningrad, with a capacity of 96,000 kilowatts, to be completed in 1933; the Dubrovsk station, also near Leningrad, with a capacity of 200,000 kilowatts, to be completed in 1932.

Railway and Road Matters.

PART II. of the Road Traffic Act, 1930, which deals with third-party risks, is to come into operation on January 1st and a draft of the proposed regulations thereon has been published.

THE Minister of Transport has intimated that it is the intention of the Government to include in the Expiring Laws Continuance Bill, to be passed during the present Session, the Canals (Continuance of Charging Powers) Act, 1922, "with a view to the further prolongation of the operation of that Act." This was a post-war measure introduced to maintain the financial condition of the canals until the time arrived when their future could be determined.

IT was stated, in answer to a question in the House of Commons recently, that under the Development (Loan Guarantees and Grants) Act, a grant had been approved, in principle, for assisting the Southern Railway in part, during a period of nine and a-half years, with the interest payable in respect of the moneys to be expended—estimated at three million pounds—on a further section of the Southampton Dock extension scheme. The present value of the grant represents slightly over 18 per cent. of the estimated total cost of the extension.

THE Railway Returns for 1929 show that the number of wagons owned by British railway companies was 700,093, a decrease over 1928 of 5988. Their tonnage capacity was, however, 7,690,405, an increase of 16,147 tons, and the average capacity was 11·20 tons, as against 11·08 tons. The total number of wagons, other than those for special traffic, of 20 tons and over was 27,688, as compared with 25,120, of which 26,112, as compared with 23,644, was allocated special to mineral traffic. The number of privately owned wagons registered during 1929 was 3884, as compared with 8671 registered in 1928 and with 25,442 registered in 1927. Included in the 1929 figures of registered wagons are 579 coal wagons of 20 tons capacity.

THE Ministry of Transport railway statistics for August, 1930, show that, compared with the corresponding month of August, 1929, there was a reduction of 6·3 per cent. in the number of passenger journeys, and it is interesting to note that the decrease in the number of those travelling at reduced fares was nearly twice as great as the decrease in those who paid full fares. The receipts from passengers fell by 9·8 per cent. The passenger train mileage was, however, reduced by only 1·4 per cent. The decrease in freight tonnage reached the high figure of 17·2 per cent., and the receipts therefrom 14·6 per cent. Freight train mileage was reduced by 8·9 per cent. The average train load fell from 130½ to 125½ tons, and the net ton-miles per engine-hour from 456¼ to 452.

AN accident of interest to locomotive engineers occurred on a Scottish railway early in the present year and was inquired into by Mr. J. L. Moore, one of the Assistant Inspecting Officers of the Ministry of Transport. The engine had been steaming badly and the enginemen took advantage of being stopped at a signal to examine the inside of the smoke-box. Whilst doing so, they inadvertently allowed the door to swing back to its full extent, in which position it projected 5ft. 2in. over the adjoining 6ft. space. Unfortunately, the door was struck by a passing train and shut to violently. Both men, who were looking into the smoke-box, were injured, and the driver died as a result a few hours later. Mr. Moore recommends that action be taken as to providing some device that would keep the smoke-box door from swinging out beyond the gauge limits.

ACCORDING to the Board of Trade export tables, the value of the railway material sent overseas during the first nine months of the present year was as follows; the corresponding figures for 1929 and 1928 are added in brackets:—Locomotives, £2,661,327 (£2,359,157, £2,746,062); rails, £1,860,297 (£2,639,605, £2,677,314); carriages, £1,443,187 (£1,722,332, £2,027,191); wagons, £2,419,704 (£1,875,912, £2,441,263); wheels and axles, £301,062 (£339,397, £623,135); tires and axles, £498,654 (£401,031, £440,818); chairs and metal sleepers, £539,695 (£365,717, £730,495); miscellaneous permanent way, £657,384 (£781,837, £1,045,058); total permanent way, £3,944,632 (£4,045,665, £5,613,924). The weight of the rails exported was 216,315 tons (243,303 tons, 309,126 tons), and of the chairs and metal sleepers, 57,128 tons (35,755 tons, 73,663 tons). During the month of September last locomotives of the value of £260,389 were shipped, which included: South Africa, £64,385; the Argentine, £42,169; India, £30,613; Straits Settlements, £10,870; other countries in South America other than the Argentine, £9389. During the same month the rails sent overseas were of the value of £214,651, and included: The Argentine, £119,681; South Africa, £82,906; British West Africa, £3131.

THE annual Railway Accident Returns give, among other particulars, the number of servants killed and injured in what are known as movement accidents, *i.e.*, those that are not train accidents, but those that occur in goods sheds, engine sheds, workshops, &c. The returns do not, however, analyse them; that is left for the annual Railway Accident Report, which is prepared by the Chief Inspecting Officer. From the report for 1929 by Lieut.-Colonel Mount, we learn that of the 202 fatal cases 60·9 per cent. were due to want of caution by the servant concerned, and 6·4 per cent. to the want of caution or breach of rules by a follow servant; 29·7 per cent. were accidental or due to misadventure, and in 3 per cent. there was some defect in method of working or of equipment. Of the 3152 non-fatal cases the proportions, in the same order, were 18·37, 6·22, 71·99 and 3·42 per cent. respectively. The contrast in the fatal and non-fatal accidents due to accidental causes or to misadventure is somewhat remarkable. There were only 2 servants killed in coupling accidents; both were due to coupling or uncoupling screw-coupled vehicles, for which the coupling pole cannot be used, and men have therefore to go between the vehicles to couple and uncouple. The pertinent rule on this particular point provides that the men must not go between the vehicles for this purpose until they come together, except when that can be done with safety to themselves. Of the 3354 movement accidents last year, 381 were inquired into by the Assistant Inspecting or Sub-inspecting Officers.

Notes and Memoranda.

A BULLETIN of some sixty-odd pages on "The Torsional Effect of Transverse Bending Loads on Channel Beams" has just been issued by the University of Illinois. The authors are Messrs. F. B. Seely, W. J. Putnam and W. L. Schwalbe, and the price is 35 cents.

AMONG the cargo in the wreck of the "Highland Hope," on the rocks off the coast of Portugal, there are thirty-six Ruston oil engines, which had been shipped by the Lincoln firm for exhibition at the British Empire Exhibition, Buenos Aires, next spring. There is, however, a possibility that the engines may be salved and put to work, as the makers have a record of an engine which was submerged in the Mediterranean for four years and is now doing good service.

THE expenditure on research by rolling mills and steel plants of the United States is, says the *Iron Age*, 0·04 per cent. of the capital invested. The average for all industries for which data are available is 1·03 per cent. The figure for chemical and allied products, spending the most, is 2·04 per cent. In an address before the American Institute of Steel Construction, Pinehurst, N.C., lately, Dr. F. Parker urged the extension of research programmes to cover production, marketing and distribution as well as the technical, and plans, he said, should be laid in terms of ten-year periods, as such are calculated "to obviate the needless changes in tonnage and profits." Quoting the most recent compilation of the National Research Council, he pointed out that all industries had an average annual research expenditure per plant of about 50,000 dollars, and that rolling mills and steel plants spent 16,200 dollars.

IN a paper recently read before the South Staffordshire branch of the National Association of Colliery Managers, dealing with the support of the roof in coal mines, Mr. W. H. Richards claimed that there is no condition of working where wood is used as a roof support in which steel would not function, not only as well, but much better. With steel props the resistance offered is more uniform throughout than with wood. It can act as a rigid prop or as a yielding prop to a predetermined amount. Better control is obtained. Steel props are safer than wood, as they have a known value of resistance. They are more easily set and withdrawn. They are cheaper than wood, for they can be set over and over again. But for steel to be absolutely successful, officials and men must be trained and their confidence gained. The system must be rigidly enforced, systematic setting and alignment being important factors. On no account should wood props be mixed with steel supports.

IT is noteworthy that among the most recently reported "boiler explosions" there are three cases of the failure of solid-drawn copper steam pipes on board comparatively small steamers. In each case the accident is attributable to local stressing and failure to anneal the pipe sufficiently frequently. In one case, that of a steam drifter, the Engineer Surveyor-in-Chief says:—"The conditions of service of steam fishing vessels is recognised as being most severe, and the steam pipe ranges should therefore be designed having due regard to this. The main steam pipe range on this vessel was designed with bends, but heavy stresses due to the movement of the boiler and machinery were imposed on the pipe neck at the flange attached to the engine stop valve. This is the second time the pipe has failed. On the first occasion a repair was effected before an explosion occurred, and the second failure was hastened by the excessive vibration following on the breaking of the propeller shaft. A stay has now been fitted with the object of relieving the pipe neck of stress, but the owners would be well advised to consider a rearrangement of the design of the range when a favourable opportunity occurs.

AT a recent meeting of the Optical Society, a new spectrophotometer was described by Messrs. H. Buckley and F. J. C. Brookes, of the Photometry Department, National Physical Laboratory. The instrument is a new type of spectrophotometer in which there are no moving optical media. Two light sources consisting of gas-filled tungsten lamps, each behind ground glass, are used. The ground glasses are used as secondary light sources of high uniform brightness, up to 400 candles per square inch. The photometric scale of the instrument is in terms of the voltage intensity relation of one of the light sources at a standard wave-length in conjunction with rotating sector discs of known transmission. The voltage intensity relation at other wave-lengths is shown to be deducible from that at the standard wave-length by simple computation. Special provision is made whereby the wave-length scale of the instrument is not affected by mechanical alteration in slit width. The Maxwellian method of view is utilised. The precision of the instrument is high, the average deviation from the mean of determinations of spectral transmission throughout most of the spectrum being about 0·5 per cent.

A NEW mineral product to be added to Canada's manufactures is zonolite, production of which has been undertaken at the new plant in Calgary of Gypsum, Lime and Albastine, Canada, Ltd. Zonolite is the non-metallic product from a simple heat treatment of vermiculite, the mineral which occurs in Nature and which is similar to crude mica, of a dark green colour. As taken from the mine the mineral weighs approximately 144 lb. per cubic foot, but on application of heat it expands rapidly till its weight is only 10 lb. per cubic foot. This light mineral product called zonolite has been found to have its chief value in the manufacture of new building materials for use as high-temperature insulation and in acoustic treatments. The product, in addition to its use for heat insulation and acoustic treatment of buildings, has other uses which are being developed. It has a lustrous gold colour and in finely ground condition with the addition of glue size is used by sign painters for gold colour work. The heat conductivity tests, it is stated, show the insulating value of zonolite to be approximately equal to cork board, and industrial applications for high-temperature insulation show its usefulness in construction of bake ovens, dry kilns, for pipe and boiler coverings, &c. Zonolite has also been mixed with wood pulp to produce an experimental plaster which has been tested in theatres in Winnipeg for acoustic improvement, with results reported as very satisfactory.

Miscellanea.

A FACTORY for the manufacture of paints and enamels is to be put up near Buenos Aires by Goodlass, Wall and Co., Ltd., the British paint makers.

A FACTORY for the working up of the barytes recently discovered at Force Crag, Lakelands, is to be arranged on the North-East Coast, probably near Hartlepool.

IT is proposed to construct two tube railways in Montreal, one running north and south and the other east and west. The total length would be 7 miles and the cost 65,000,000 dollars.

AN artificial silk factory with an output of 5000 kilos. a day is to be put up at Burgos, in Spain, by the Sociedad Espanola de Seda Artificial. When this factory is completed, Spain will probably be free from the necessity to import artificial silk.

THE first of the pulverised coal boilers at N'Kana, Northern Rhodesia, which are being supplied by International Combustion, Ltd., is to be in service at the end of this month. The first two of the units will be of 40,000 lb. per hour each, and will be followed by four units of 80,000 lb. per hour each.

A USEFUL pamphlet by P. Good, describing the organisation of the electrical industry in Great Britain, has just been published by the Institution of Electrical Engineers. About sixty organisations are described, beginning with the Institution of Electrical Engineers and finishing with the British National Committee of the World Power Conference.

IN an effort to establish a three-day mail service between London and New York, the United States lines have placed before the Navy Department plans for two new 50,000-ton liners equipped with catapults to enable mail-planes to be launched from them some 600 or 1000 miles at sea. The new liners are expected to be speedier than either the "Europe" or the "Bremen," and to cost about £6,000,000 each.

IT has recently been brought to our notice that, among the relics of the ill-fated Andrée Expedition towards the North Pole, was found, beside the body of the explorer himself, his diary, with, attached to it, a Koh-i-noor lead pencil. The pencil, which had, apparently, been used to write the diary, was still in good condition when it was found, despite the fact that disaster overtook the Expedition more than 33 years ago, while we understand that the diary was readable from beginning to end.

A BROADSHEET of pictures, depicting the remarkable variety of engineering products to be seen in the Birmingham section of the British Industries Fair next spring, has been issued to most countries abroad, with text in the appropriate language, outlining the chief groups of exhibits and reasons why buyers from everywhere should "Come to Birmingham." Nine editions have been distributed by British Consuls and agencies in the following languages:—English, French, Portuguese, German, Spanish, Italian, Swedish, Dutch and Danish.

THE official Returns rendered to the Electricity Commissioners show that 963 million units of electricity were generated by authorised undertakers in Great Britain during the month of October, 1930, as compared with 949 million units in the corresponding month of 1929, or an increase of about 1·5 per cent. During the ten months of 1930 up to the end of October, the total amount of electricity generated by authorised undertakers was 8684 million units, as compared with 8240 million units for the corresponding period of 1929, representing an increase of about 5·4 per cent.

ACCORDING to the monthly report of the National Federation of Iron and Steel Manufacturers, the number of furnaces in blast fell by eight during October to 96. Production of pig iron in October amounted to 415,000 tons, compared with 425,000 tons in September, and 688,700 tons in October, 1929. The production includes 122,200 tons of hematite, 155,800 tons of basic, 105,000 tons of foundry, and 21,200 tons of forge pig iron. The October output of steel ingots and castings amounted to 512,500 tons, compared with 580,600 tons in September, and 889,800 tons in October, 1929.

THE nominees to the Fuel Research Board, put forward by the South African Department of Mines and Industries, have been approved by the Governor-General. The Board will consist of Dr. J. S. van der Lingen, B.A., Ph.D. (Chairman), Dr. A. W. Rogers, D.Sc., F.R.S., Dr. V. Boaman, M.A., Ph.D., Mr. John Roy and Mr. J. T. Williams. The Chairman is Professor of Physics at the University of Pretoria. The Board will carry out researches into the fuel resources of the Union, with particular reference to possible sources of liquid fuel, and will finance its work from the grant of £30,000 voted by Parliament for the purpose last session.

THREE new air lines have been added to the Russian network this summer, and have increased the total length of airways from 7438 miles to 11,445 miles. One of the lines, running over the Caucasus Mountains to Baku *vid* Tiflis, completes the former air connection between Vladikavkaz and Baku. The two others run through Siberia, one, from Moscow to Irkutsk, being the first step towards establishing services to Japan and China, the other connecting Semipalatinsk, in South Siberia, with Alma-Ata, in the Soviet Republic of Central Asia. New lines planned for the next three years will raise the total length of airways to 25,955 miles.

RECENTLY, the Raymond Concrete Pile Company, Ltd., of Montreal, Quebec, established what is thought, says the *Canadian Engineer*, to be a speed record in driving wooden piles in Western Canada. At Saskatoon, it drove 4372 wooden piles of 40ft. length as foundations for a grain elevator, and for an elevator at Moose Jaw it drove exactly the same number of 30ft. piles. On each job it used two equipments. The Saskatoon job was started on August 1st and completed August 25th. The driving there was extremely hard, requiring in many cases as much as 18 minutes per pile. At Moose Jaw the driving was also difficult, but on account of the piles being shorter, the job did not take so long. This work was started on August 30th and completed September 17th.

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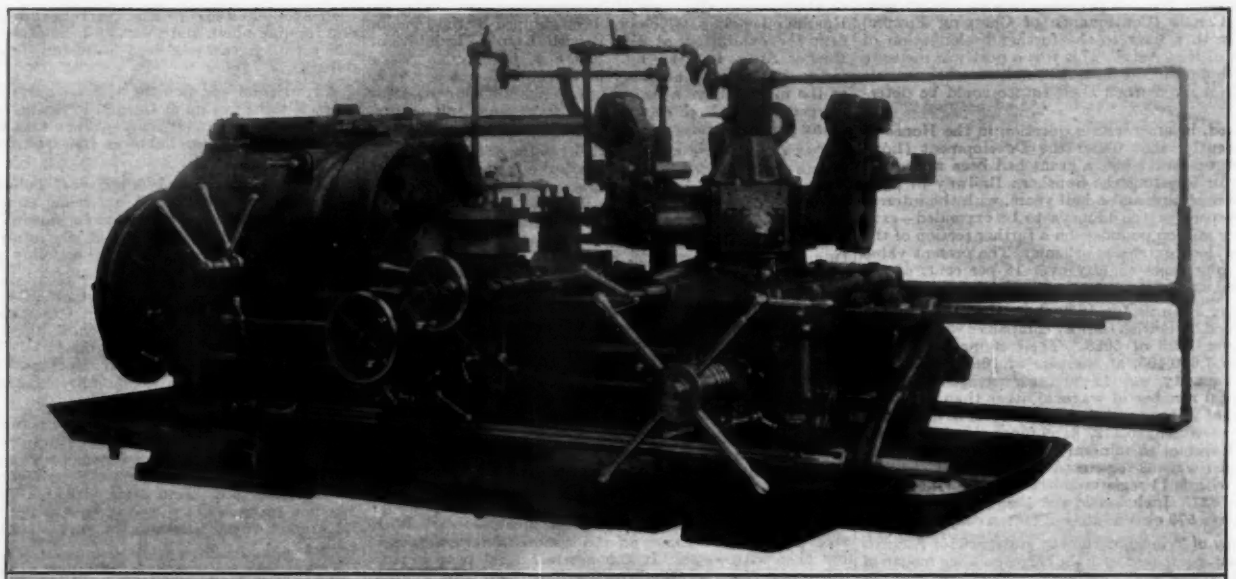
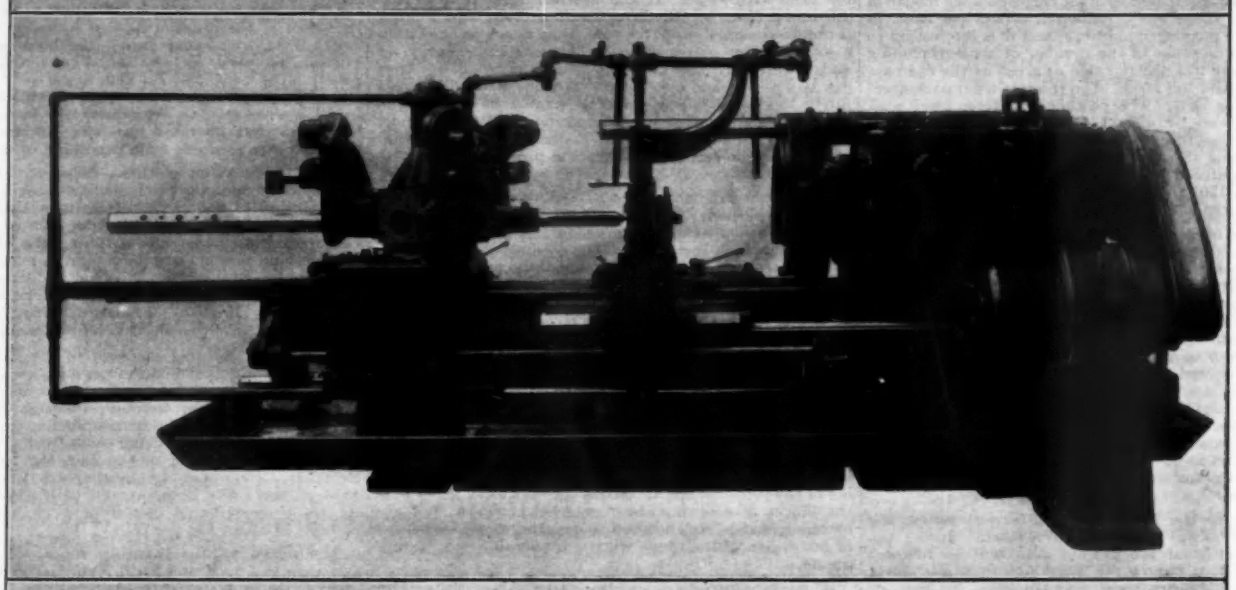
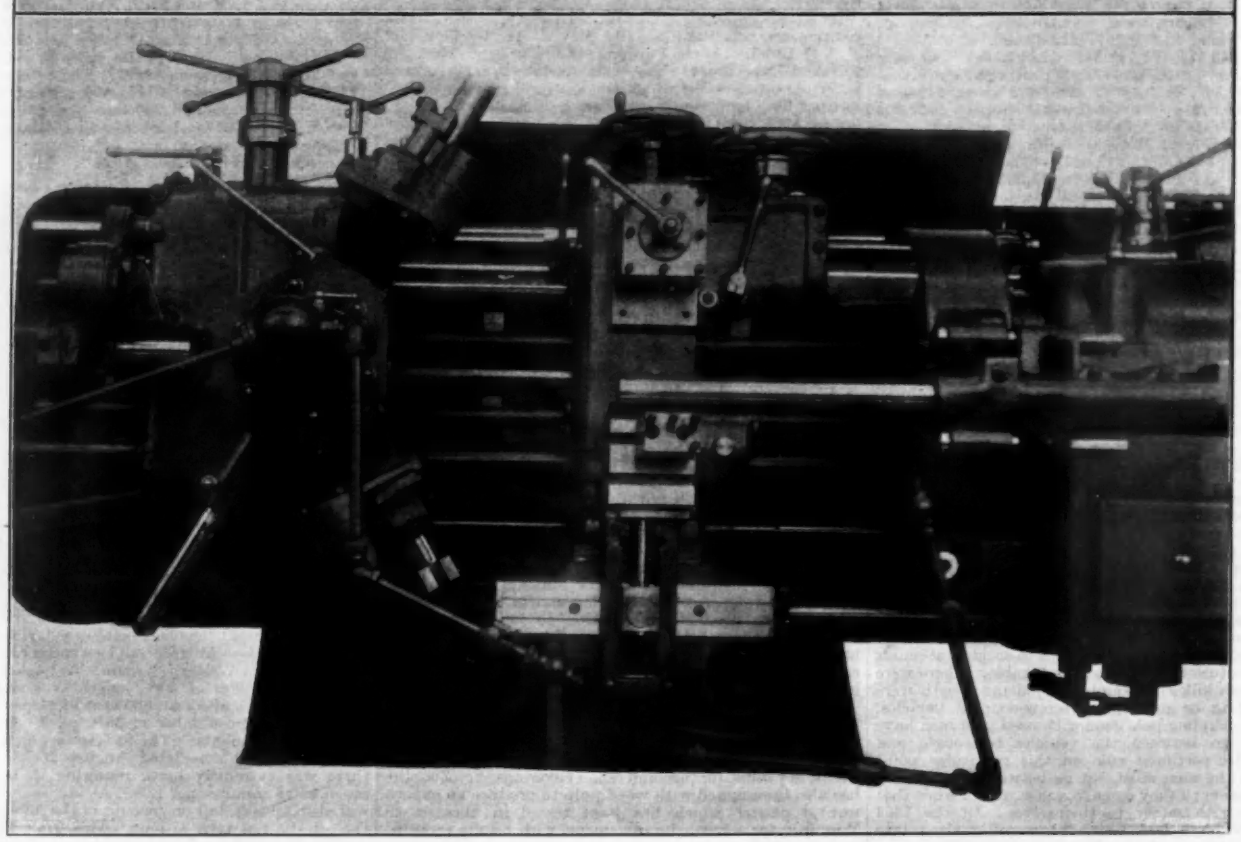
(*For description see page 603.*)







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The Metallurgist.

THE NOVEMBER NUMBER OF THE MONTHLY METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE.

THE ENGINEER.

VOL. CL No. 3907

NOVEMBER 28, 1930.

High Pressure Boiler Tubes.

THE paper read by Mr. Dorey, of which we conclude an abstract in our present issue, is of the greatest interest to designers of boilers and superheaters. Its object, we are given to understand, was to draw attention to the lack of any precise rule for determining the thickness of the tube walls of the generating and superheater tubes employed in modern high-pressure water-tube boilers. It was written by a principal engineer-surveyor of Lloyd's Register of Shipping, and was addressed to members of the Institute of Marine Engineers, and its outlook is mainly marine; but, as the subsequent discussion showed, it has a much wider appeal, for the problem is the same for the land as well as the marine water-tube boiler. The present position with regard to the marine boiler may be stated in a very few words. The first rule fixing the thickness of tubes for water-tube boilers would appear to have been formulated in 1920, by the British Marine Engineering Design and Construction Committee, over which the late Mr. A. E. Seaton so ably presided. That Committee comprised representatives of the Institution of Naval Architects, the Institute of Marine Engineers, the North-East Coast Institution of Engineers and Shipbuilders, the Institute of Engineers and Shipbuilders in Scotland, the Liverpool Engineering Society, and the three large classification societies, Lloyd's Register of British and Foreign Shipping, the British Corporation for Survey and Registry of Shipping, and the Bureau Veritas International Register of Shipping. The tube thickness in one-hundredths of an inch is given by the formula :—Working pressure multiplied by the external diameter of the tube and divided by a constant, which is sixty for the fire-tube rows and seventy-five for the other tubes. To this result a factor of eight is added. This result was approved by the Board of Trade and the classification societies in 1920. Practically the same formula appears to have been adopted by the Board of Trade authorities, and it is given in the 1928 Instructions for the Survey of Passenger Ships. In this particular formula the factors for the fire-row and other tubes are slightly altered, being given as fifty-five and seventy-five respectively, while an addition of seven instead of eight is made. This formula, it is stated, may be used for tubes up to a working pressure of 250 lb. per square inch. By the adoption of suitable factors, the formula, it is true, may be adapted for higher working pressures, but at such pressures it gives a minimum thickness which is too great for practical purposes. At the present time working pressures up to 550 lb. per square inch are in use in British steamships, and land boilers are working at a pressure of 1100 lb. per square inch, while there are under construction boilers designed to work at 1400 lb. per square inch. On the Continent not only are similar pressures in use in several land installations, but there is more than one installation of Benson critical pressure boilers on land and an experimental installation in a cargo ship. British boilermakers rightly complain that whilst American and German authorities have legislated for these higher pressures, each design for a high-pressure installation put forward in Great Britain is dealt with by the Board of Trade on its own merits, a procedure which often leads to delay in the approval of plans and the ordering of tube material.

The problem presented, it seems to us, is to formulate without undue delay a specification and rules, which, while being acceptable to the Board of Trade and the classification societies, will cover a greatly increased range of working pressures. Such rules should take fully into account the newest information on the physical properties of mild steels, and the newer alloy steels now used in tube making, under high-temperature conditions. The important effects of creep and the change in structure of the cold-worked expanded ends of the tubes should not be overlooked. In any such investigation it will be most important to make some allowance for corrosion, both internally and externally, but we believe that with the use of pure de-aerated feed water and oil fuel firing, coupled with the external cleaning of the tubes by scientifically designed steam blowers, and the regular cleaning and polishing with graphite compound of the inside of the drums and tubes, the amount to be allowed for corrosion will be practically negligible. If we take, for a moment, the analogy of a chemical test tube, it will be remembered that in order to avoid heat stresses when boiling a liquid the thinnest glass is to be preferred. In the light of the Yarrow experiments on thin-walled tubes, we know that the bursting strength of such a tube is enormous. If, however, creep effects are to be allowed for effectively, a somewhat thicker tube must be employed, as, obviously, a too thin walled tube will fail earlier than one of greater thickness, owing to the higher mean stress resulting from the plastic flow of the material in the wall section. The question of the correct thickness for best working conditions, whilst important for generating tubes, assumes an even more serious aspect in the case of the tubes in a superheater. Other important questions bearing directly on tube strength are the homogeneity of the material supplied by the steel maker to the tube works, and its inherent suitability for the process of tube making, whether by hot or cold drawing. Again, appropriate mechanical tests and chemical analyses are required, bearing in mind the special heat-resisting qualities of some of the more recent alloy steels. With regard to mechanical tests, it may be necessary to modify some of the existing tests, having in view the very special and unusual properties which some of the new steels possess when exposed to very high temperatures. Again, the degree of finish and dimensional accuracy which is given respectively by the contrasted methods of hot and cold drawing would seem to open a valuable field for discussion and investigation. It will, we think, be generally admitted that for very high-pressure work tubes of superior quality to those generally supplied for moderate pressures are without doubt required when the very difficult service which these tubes are called upon to bear is taken into account.

The question remains as to how best the desired end may be accomplished. In considering possible ways, we cannot overlook the excellent work done by the late British Marine Engineering Design and Construction Committee, which was brought into being more than twelve years ago to co-ordinate the various rules then in existence for the construc-

tion of steam engines and boilers. Its main work was already done in 1918, but its activities were prolonged until 1927, when it was disbanded. The Board of Trade and the classification societies worked in closest connection with that Committee. The possibility of reconstituting such a body to deal with the question of tubes for high-pressure water-tube boilers, and also probably different forms of high-pressure drums, must be taken into consideration. There already exists, however, a Consultative Committee of Shipbuilders and Marine Engineers appointed to confer with the Board of Trade, on which there are well-chosen representatives of the Institution of Naval Architects, the Institution of Marine Engineers, and shipbuilding interests on the Clyde and Tyne and at Belfast. Under the experienced chairmanship of Sir Charles Sanders, it is quite possible that the basis of this Committee might be broadened, in order to enable it to deal adequately with the question involved. One point cannot be overlooked. It is that land practice in high-pressure water-tube boilers has tended to advance more quickly than marine practice, and as the leading British constructors of boilers are interested in both land and marine boilers, it is very essential that any rules made should be equally applicable to both types of boiler. At the present time, both American and German boiler designers are guided, to a large extent, by the standard rules prepared by the Boiler Code Committee of the American Society of Mechanical Engineers, and by similar rules which have been drawn up and approved by the German authorities for the construction of land boilers. In our own country it might be possible, especially having in view the rapid advance towards higher pressures in land installations, to arrange for our own Institution of Mechanical Engineers to perform the very useful task of bringing together a panel of engineers who could deal effectively with the position we have outlined. The work would be done, we are sure, on the broadest possible basis, and in the closest co-operation with the other interested authorities, such as the Board of Trade and classification societies. If, at an early date, the wider rules, together with specifications for the different tube-making materials, were made available, they would, we are sure, greatly assist all the industries which are engaged, directly and indirectly, in the production of a scientifically designed high-pressure water-tube boiler.

Railwaymen's Pay.

It is expected that there will be a meeting to-day—Friday—between the railway general managers and the representatives of the three railway trade unions to discuss the proposals put forward by the former for a modification of the rates of pay and conditions of service of all employees subject to the jurisdiction of the National Wages Board. In order that our readers may have some acquaintance with the matter to be discussed, we propose to give, without any comment, a review of the situation. Let us consider, in the first place, the companies need for such drastic proposals as they have put forward. It is quickly seen in the fact that for the first forty-six weeks of the current year the traffic receipts, as published, showed a decrease, when compared with 1929, of roughly £9,000,000, and a statement issued officially by the companies puts the estimated loss for the whole year at £10,500,000. It must, moreover, be borne in mind that whilst the companies benefited throughout the whole of last year by the voluntary reduction of 2½ per cent. in salaries and wages—estimated to save £3,000,000 a year—the reduction ceased this year in the middle of May. On the other side of the account, it must be remembered that nothing is included in the weekly traffic tables for the receipts from road transport. Supporters of the men's opposition on the present occasion appear to think that these receipts will greatly change the situation. There is no doubt that a considerable sum will accrue from this traffic, but we fear that the men and their friends will be disappointed by the actual amount. It is certain that the purchase of the road services, or of an interest therein, was very costly. The transport companies had not only dug themselves well in, particularly after they saw that the railways were anxious to buy them up or share, but they had fine equipment and a good, growing business. The railway companies have been reproached for having allowed the road transport people to get so firmly established, but it must be remembered that they had no powers to embark in road services, and the attempt made in 1922 by the London and North-Western and Midland companies was, mainly because of the attitude of the Ministry of Transport at that time, not encouraging. The railways were then, and for some time afterwards, engaged in the problems of grouping, and their hands were too full for them to embark on such an extensive, complicated new departure, which, moreover, would involve opposition from strong vested interests, and from local authorities which feared the disappearance of competition; to these had to be added possible objection from the Ministry of Transport, and the certainty of a big fight in the House of Commons.

Coming now to a consideration of the details wherein economies in railway working are possible, we may recall that in The Engineer of April 4th last, we compared the figures of 1929 with those for the year 1924, which was the first after the grouping of the railways had become effective. We showed that the passenger train mileage was 7 per cent. greater in 1929 than in 1924, but despite that there was a loss of 10 per cent. in the passenger receipts. We found an excuse for that in the praiseworthy efforts of the companies to retain their traffic against road competition. Freight traffic receipts, on the other hand, were up by £200,000, but it took 400,000 more train miles to earn that increase. There was a drop of £3,000,000 in traffic expenses, but as £3,600,000 were saved in salaries and wages—owing mainly, we suggest, to the 2½ per cent. deduction, which was not operative in 1924—other expenses in the traffic branch must have risen by £600,000. In the engineering departments, in which the 2½ per cent. reduction applied only to a few grades, *e.g.*, platelayers and signal fitters, there was a saving of 8 per cent. in the civil engineering department and of 4 per cent. in the maintenance and renewal of locomotives, carriages, and wagons. Thus we reach the point that it is in the operating services that economies are needed, and in a consideration of that feature we must once more go back to the period when the railways were under the control of the Government, which control extended from August, 1914, to August, 1921. It is a familiar story, but, in the circumstances, certain facts must be retold. Although it may be said to have begun with the first war bonus in February, 1915, it will suffice to relate the happenings of the eighteen months or so following the Armistice of November, 1918. The consideration of the eight-hours' day was promised for "within a month of the cessation of hostilities," and in December, without any consultation with the companies, the shorter day was conceded by the then President of the Board of Trade. At the same time a promise was made that the men's pay and conditions of service should be looked into. That was done in March, 1919, and at the instigation of the Government—which, be it remembered, was the paymaster—revised conditions of service were conceded. These latter, in the granting of the guaranteed week, and the guaranteed day, and payment for overtime, night duty and Sunday duty, were of a most generous character. The rates of pay were not interfered with. That change was left till standard rates for the whole country could be agreed to. The rates for locomotive men were disposed of in the following August, and for the other grades were decided upon in March, 1920, and the immediately succeeding months—an alleged delay in dealing with the other men was made the ostensible reason for the general railway strike of September–October, 1919. The standard rates then agreed to resulted in considerable advances in pay all round. It is these burdens, which the companies were made to bear at the time when the railways were under Government control, that it is now sought to remove. That there is justification for relief is to be seen in the fact that the railwaymen, subject to the National Wages Board, are being paid 120 per cent. more than in 1914, as compared with 70 to 75 per cent. more in industry in general, even although the cost of living is now only 56 points higher. It might be argued that in former days the poor pay of railwaymen was notorious. That had, however, been changed by 1914, as a result of the revised conciliation scheme established in November, 1911, after the strike of the preceding August. The present proposals of the companies are, no doubt, drastic. They include an immediate reduction of 6s. per week for adults, and the reduction of the present minimum rate of 40s. to 38s., a reduction of 3s. in the pay of the junior male staff and of all females, and of £10 to £15 for the adult male salaried staff. The guaranteed week and day and payment for Sunday and night duty are to be abolished, the forty-eight hours are to be worked as required, and are to include Sunday duty; overtime, including that worked on Sunday and on night duty, is not to count until forty-eight hours have been worked during the week in question, and is to be paid for at time and a-quarter.

Fortunately for the general public, who are intimately associated in many ways with this question, and in the interests of justice for both the companies and the men, this question will virtually have to be settled by the chairman, Sir Harold Morris, and the four "users of railways," who together are the independent members of the National Wages Board, which body comprises also six representatives of the companies and six of the men. The legislation on this question, laid down in the Railways Act, 1921, allows for all differences to be settled between the individual company concerned and the men, and, failing agreement, the question may be referred by either party to the Central Wages Board, which represents all the companies and men, whence, still failing agreement, it may go to the National Wages Board. It is almost safe to anticipate that these proposals will reach the last-named tribunal, and there the companies, as the prime movers, will state their case. The men will reply, and, in due time, the Board will give its award. It is only right that it should be added that, unfortunately, neither side is compelled to accept it. That was revealed when, after an award in December, 1923, which increased the enginemen's mileage for a day's pay, the members of the Associated Society of Locomotive Engineers and Firemen refused to accept it, even although their representative on the National Wages Board had signed the award. In this relation we are glad to notice that Mr. J. H. Thomas, when addressing his constituents at Derby last Friday evening, said: "My answer to those who talk of an immediate crisis is 'No! Conciliation machinery is there and must be used.' I refuse to be pessimistic."

Institute of Marine Engineers.

TUBES FOR HIGH-PRESSURE WATER-TUBE BOILERS.

No. II.*

We continue below our account of the discussion on Mr. Dorey's paper which was read on the evening of November 11th, the reprint of the abridgment of which is concluded on page 591 of the present issue.

Major W. Gregson, of Babcock and Wilcox, Ltd., in a written communication, pointed out that the author had suggested that the radiant-heated type of superheater was not likely to be favoured for marine work. In the application of modern steam boilers to high-powered ships much stress was laid on space limitations, and the result was that the interdeck type of superheater tended to become more and more congested in design in order to conform with the available space. It would appear that superheater accessibility under such conditions might be enhanced by arranging two superheaters in series—a first-stage interdeck type superheater of less crowded design followed by a modified form of radiant-heated superheater for second-stage heating. The latter superheater need not be in direct flame contact, but could be incorporated in one of the furnace walls and sufficiently shielded from direct furnace effect to avoid the objections normally raised against radiant heat superheaters for marine work. Furthermore, as it would receive already superheated steam from the primary unit, there would be no possibility of re-evaporation having to take place within it.

Mr. T. H. Burnham, of Hadfields, Ltd., in a written communication, stated that he was specially interested in the sections dealing with materials, as there was no doubt that with higher temperatures and pressures in steam raising the design and reliability of the plant depended on the materials employed.

With regard to mild steel tubes, Mr. Dorey's remarks on the necessity for soundness and homogeneity of the steel were to be supported. In the firm which he represented, Sir Robert Hadfield had spent many years in developing means of ensuring soundness of steel, and it might be noted that at the present time the firm was making special tube steel of high purity and homogeneity for high-duty superheater tubes. Those tubes were subjected to the most rigid inspection for homogeneity, and the slightest flaw on either the inside or outside surface led to their rejection.

Where special steels were employed for high-temperature use they should have the same reliability over long periods of working that mild steel had at the ordinary operating temperatures and pressures. The additional capital expenditure was then justified by the increased overall efficiency. A number of materials were now available for high-temperature service, including the steel referred to in Fig. 7. There was also a certain amount of data available on creep strength, in the light of which calculations of tube thickness had to be made. The requirements of these special steels were, however, very exacting. They had to meet specifications with respect to bulging, expanding, flattening, &c., in the cold, as well as to possess special properties at high tem-

* No. I. appeared November 21st.

peratures. Whilst the "Era" steel referred to, possessed a good resistance to creep—above that of the so-called 18×8 corrosion-resisting steel in the temperature range 400–550 deg. Cent. (750–1000 deg. Fah.)—combined with improved resistance to oxidation and corrosion both by exhaust gases and condensed sulphurous liquors, and a coefficient of dilatation which was the same as that of ordinary steel, it should be noted that its maximum retention of strength might be seriously jeopardised by retaining such a degree of mildness and ductility as was necessary to enable it successfully to withstand certain cold working operations, such as the machine-made hairpin return bends for superheater tubes.

Everyone knew that practice was a compromise. He submitted that Mr. Dorey's suggestion of co-operation of steel makers and tube makers was a valuable one for the solution of the problem in connection with special tubes. It might be found practicable to permit a modification in the tests at ordinary temperature in the interests of the retention of mechanical strength at operating temperatures. Co-operation between engineers and steel makers was equally essential, and the requirements of engineers as regarded permissible rate of creep for the components of steam piping systems—bolts, tubes and tube flanges—were being set forth in papers like that of Mr. Baumann before the Mechanical Engineers and the present one by Mr. Dorey. Such information enabled the steel maker to decide from which steels the choice should be made, in order that the other properties might also receive due consideration. He submitted that Mr. Dorey's paper did a great deal to show when special steam pipes were necessary and what their mechanical properties must be. It also showed that the materials were available for engineers who had such schemes under consideration.

Mr. C. Dennis Heck, of Lloyd's Register of Shipping, in a written communication, observed that the author had emphasised the necessity for care in the selection of steel billets intended for the manufacture of the tubes of high-pressure water-tube boilers; he further considered that it was desirable that steel makers and tube makers should confer with one another in order to draw up a suitable specification for the billets. It was to be hoped that if such a specification were evolved it would include requirements ensuring, above all things, that a high degree of mechanical soundness would be consistently obtained. When steel had to be drawn it was, in his opinion, not sufficient that the chemical composition and particulars of the mechanical tests only should be specified. The limiting portions of the ingot from which the billets might be derived should also be defined with precision.

During the discussion on the paper one had heard that segregated steel had been used with success in the manufacture of tubes, but while slight local excesses of such elements as phosphorus and sulphur might be present without harm, it appeared to be essential that sufficient discard should be taken from the ingot to ensure that piping and blow-holes would be definitely eliminated. If they were asked, steel makers could, no doubt, make many useful suggestions as to the best practice regarding the conditions of pouring, the shape of the ingot and the percentage of top and bottom discard. Those matters would have to be carefully defined in any specification designed to cover best-quality billets.

It might be urged that such requirements would entail a very wide and rigid system of inspection, but it should also be noted that a similar system had been widely employed without difficulty in the manufacture of shell billets, and it was surely possible to adapt it to the manufacture of billets intended for water tubes of high-pressure boilers.

Mr. J. Pringle, of Lloyd's Register of Shipping, Sheffield, dealt in a written communication with the inspection side of the problem, which, in his opinion, was very important. It was recognised, he said, that only non-segregated steel should be used for tubes for high temperatures. Under some methods of manufacture it was more difficult to make a first-class tube, as non-segregated steel did not stand as much punishing as did ordinary segregated steel. That statement applied particularly to piercing by the rotary process. In some cases a tube had been known to be broken in the middle of its walls, the defect being most troublesome to detect either by external or internal inspection. Such latent defects were very difficult to discover unless the inspector knew the inherent defects for which he had to look. Any such knowledge certainly needed considerable experience with the various methods of manufacture, as the defects to be found varied very considerably under the different methods employed.

The external examination could be assured by the electro-zincing process, which indicated clearly the most minute fracture. With regard to the mechanical testing of tubes to B.S. 53 and the Admiralty specification, those specifications were sufficient for ordinary tubes, but did not appear to be sufficient for tubes designed for high pressures or high temperatures. He suggested that instead of the flattening test at the end of each tube, an expanding test at each end of the tube should be adopted. Such a test would show up any external or internal defect, whereas the flattening test only proved the two sides externally. The cost should not be any greater, as the expanding required could be done on the existing machinery used for the bulging of tubes. As an alternative test a ring about 1in. or 1½in. might be taken from the tube, cut through on one side and bent round inside out to form a tube again of the original diameter. That would show up any likely internal defects.

Another point was worthy of notice: while the author said that the tube should be thoroughly clean inside, it was equally important that the boiler should also be carefully examined to see that there were no scale pits caused by the swaging in of the ends during manufacture. It was understood that a new machine was now being adopted for machining the internal parts after the swaging operation.

Mr. Robert Waddell, of Brown, Bayley's Steel Works, Ltd., Sheffield, referred in a written communication to the author's statement that oxidation of the tubes was more likely to occur on the inner surface in contact with the high-temperature steam than on the outer surface which was in contact with furnace gases. That did not appear to be supported by any evidence, and it seemed unlikely to be true for steam temperatures under 500 deg. Cent., in view of the inevitable temperature gradient between the outer and inner tube surfaces. The furnace gases were also frequently additionally corrosive, by reason of the presence of oxides of sulphur.

When dealing with creep stresses the author had quoted a conclusion of Mr. H. L. Guy that "ordinary carbon steels might be used at a temperature of 900 deg. Fah., with the same factor of safety as at 700 deg. Fah.—*i.e.*, with the same creep rate—provided that the stress was reduced by 60 per cent." He found that conclusion to be very optimistic. The drop between 800 deg. Fah. and 900 deg. Fah. was probably of the order of 45 per cent., and the difference—15 per cent.—seemed very small to ascribe to the range 700 deg. Fah. to 800 deg. Fah. He would ask whether the author could produce any experimental evidence in support of those figures. Referring to alloy elements in steel tubes, the author had cited the use of "Enduro" metal—a "stainless" iron of about 17 per cent. chrome and fairly high silicon—to which he gave a bad character by reason of its brittleness when held for long at temperatures of 1000 deg. Fah. Such high-chromium irons were known to be brittle even in the cold state, and it was not clear why the author dismissed summarily the straight chromium group of materials on the behaviour of perhaps the least suitable of that group. For resistance to oxidation up to temperatures of 800 deg. Cent.—a figure far beyond the present necessities—a much lower chromium than 17 per cent. would suffice, and materials containing 12–14 per cent. of chromium, having very good physical properties both in the cold and the hot state, could be produced. So far as he knew, the experiments to determine the creep rate of those medium-chromium steels had not yet been carried out through a sufficiently wide range of temperatures, or for a time sufficiently long to enable an accurate figure to be quoted which might be used as the basis for superheater tube design. The preliminary investigations, results of which were given before the Liverpool Engineering Society on December 4th, 1929, seemed extremely encouraging, and they should be followed up, before resorting to the austenitic nickel-chromium steels with various additions of tungsten, molybdenum, &c. The danger of intergranular embrittlement in the austenitic steels was now so well known and appeared so extremely difficult to guard against that the virtues of the chromium materials ought to be thoroughly explored before such steels were discarded for superheater work. In his—Mr. Waddell's—opinion those steels, while possessing a lower tensile strength at high temperatures than the austenitic steels, would be found to preserve their physical characteristics unimpaired over a very much longer time.

Mr. S. J. Thompson, the governing director of John Thompson Water-Tube Boilers, Ltd., of Wolverhampton, in a written communication, stated that his firm was most interested in the superheater problem. It has installed many superheaters for temperatures of 750 deg. Fah., and experience had also been gained with superheaters designed for temperatures considerably in excess of that. With ordinary mild steel tubes no difficulties at those temperatures had been met with. The experience already gained showed that with a suitably designed superheater, temperatures of 900 deg. Fah. could be obtained with a good margin of safety using mild steel tubes.

With regard to the corrosion of superheater tubes, it appeared that at the temperatures named in the paper, taking in view the higher pressures, serious disassociation of the steam was unlikely, and it might be expected that the steam would produce a thin tenuous protecting scale on the inside of the tubes. His firm believed that the corrosion of the tubes externally was likely to be more troublesome, as the tube externally was in contact with furnace gases of fluctuating composition which contained some sulphur compounds. The attack from that cause with temperatures up to 650 deg. could be prevented by aluminising. In that process aluminium was applied to the clean surface of the tubes by means of a metal spraying pistol. The aluminium coating was then heat-treated at 1300 deg. Fah. for a few minutes, the covering being converted into an aluminium iron alloy, which was resistant to oxidisation and sulphurous attack. The surface also became very hard and stood up well to erosion. The coating had no bad effect on the mechanical properties of the steel or on the "creep," neither did it embrittle the tube or cause intercrystalline breakdown. His firm had now had considerable experience with the aluminising process, and found it of great assistance for both cast iron and steel when those metals were subjected to high temperatures. A number of superheater tubes had been aluminised, and it might be recalled that the process was used with success on the superheaters of the Atlantic liner "Bremen."

In the paper the bad effects of the segregated inclusions were mentioned, but there were also the oxygen inclusions. During the process of making weldless steel tubes it was possible to roll in scale and thereby to cause oxide inclusions, which were difficult to discover either by mechanical or by chemical tests. Such tubes were, fortunately, not numerous, but they often failed in service. That point was mentioned because it was an interesting fact that such tubes could not be aluminised, since the presence of the oxide prevented the absorption of the aluminium into the steel.

Mr. J. Calderwood, of Sulzer Brothers, dealt in a written communication with several theoretical points in the paper, and said that he preferred Haigh's theory to Guest's law. He gave some results which he had obtained from experiments made some years ago, with regard to the transfer of heat from air to water and applied these results critically to the formula proposed by Mr. Dorey.

Engineer Rear-Admiral J. Hope Harrison, in a written communication, pointed out that so far a very considerable amount of research had been carried out in order to obtain a tube that would satisfy certain tests. When we examined those tests, although it might have to be admitted that the material which would successfully stand up to them could not be of very inferior quality, still we found that they were chiefly devised to ascertain whether the tube could be cheaply worked into a water-tube boiler and would withstand a certain pressure in place. An examination was seldom made of the material from which the tubes were manufactured, with a view to ascertaining whether the tube would give good service after it had become part of a boiler. Experience had shown that the life of a tube depended to some extent on the structure of the material from which it had been manufactured. In many cases the user specified nothing about the steel; very often basic steel was used. Details of the steel from which tubes were made had in the past generally been specified only by the tube maker, and he had been reluctant to use any steel except that which experience had taught him he could fabricate into tubes cheaply and which would withstand certain physical tests and also pass a visual examination.

In order to show up any marks on the outside of the tube it was zinced; but the internal surface was not zinced, and could only be cursorily examined visually. It was on that surface that rapid deterioration nearly always took place. If the water-tube boiler was to become standard for merchant ships, the life of tubes should be as long as possible. Apart from the cost of re-tubing, the time lost while a ship was being re-tubed was important. If boilermakers and tube manufacturers were wise, they would take every precaution that experience of water-tube boilers had shown to be necessary, in order to avoid the criticism that must be inevitably levelled if the high costs of maintenance were to wipe out any gain in fuel economy.

The author also considered questions of design. The designer sat aloft and sneered at the inefficient operator, who was less articulate, when the fault was often the designer's, because he had been ignorant of the precise conditions under which his design would have to be operated. Although the designer might be able to say, approximately, what thickness of tube would withstand the heat and fluid stresses to which it was proposed to subject it when perfectly clean, no experienced operator forgot that tubes were never clean internally or externally; over 90 per cent. of tubes were normally reduced 70 per cent. in thickness locally in the short space of from eight to ten years, even with very careful operation, and in some cases that reduction took place in as many months. It was unwise therefore to speak of determining the thickness of tubes by calculating the stresses they had to withstand when clean and then adding what would—were there no such thing as corrosion, scaling, &c.—normally be a reasonable factor of safety.

The high-pressure boiler had not been long enough in service to enable sufficient experience to be gained as to the best material to be used, but there appeared to be no reason to doubt that a steel containing 0·1 to 0·17 per cent. of carbon would give satisfactory service at temperatures up to 800 deg. Fah. if the steel was carefully made and inspected. He considered that a rigorous inspection of the steel from which tubes were to be made should be carried out by the ultimate user at the steel makers, and that no inferior material should be allowed. The author might have stressed even more the point that experience had shown that cold-drawn steel was preferable to hot-drawn steel, and that the "gun-barrel finish," which a few final cold passes gave, was cheap in the long run. There was a danger that if tube makers did not realise that water-tube boilers must not run

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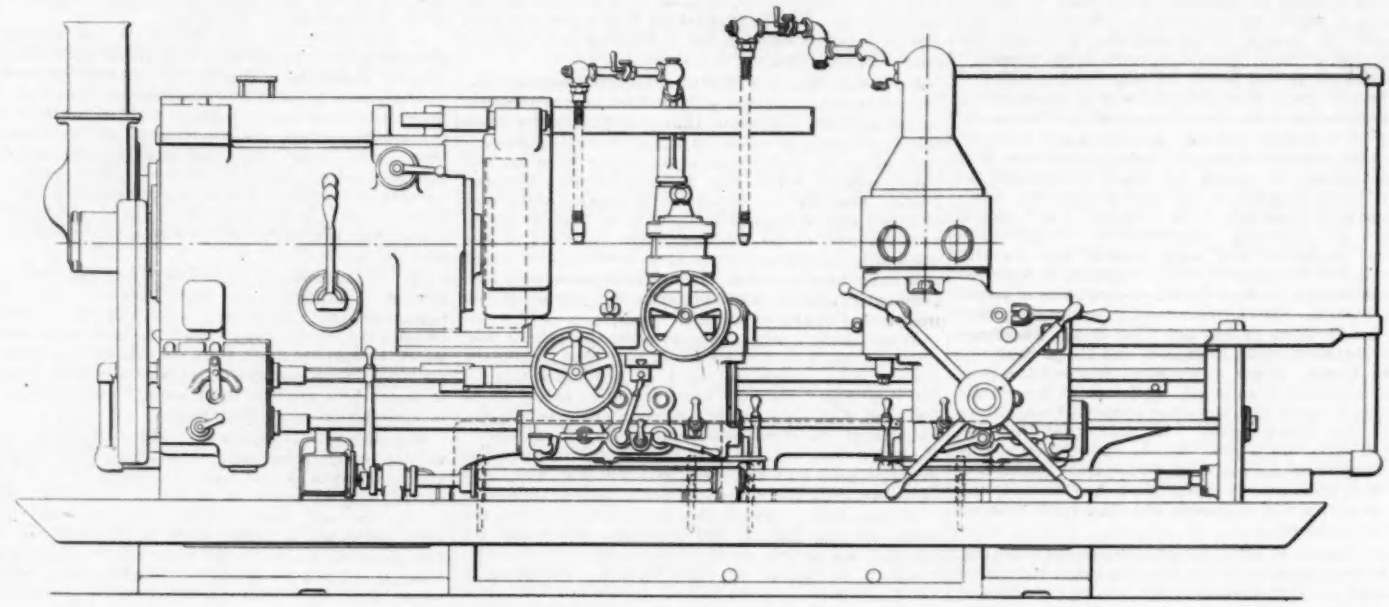
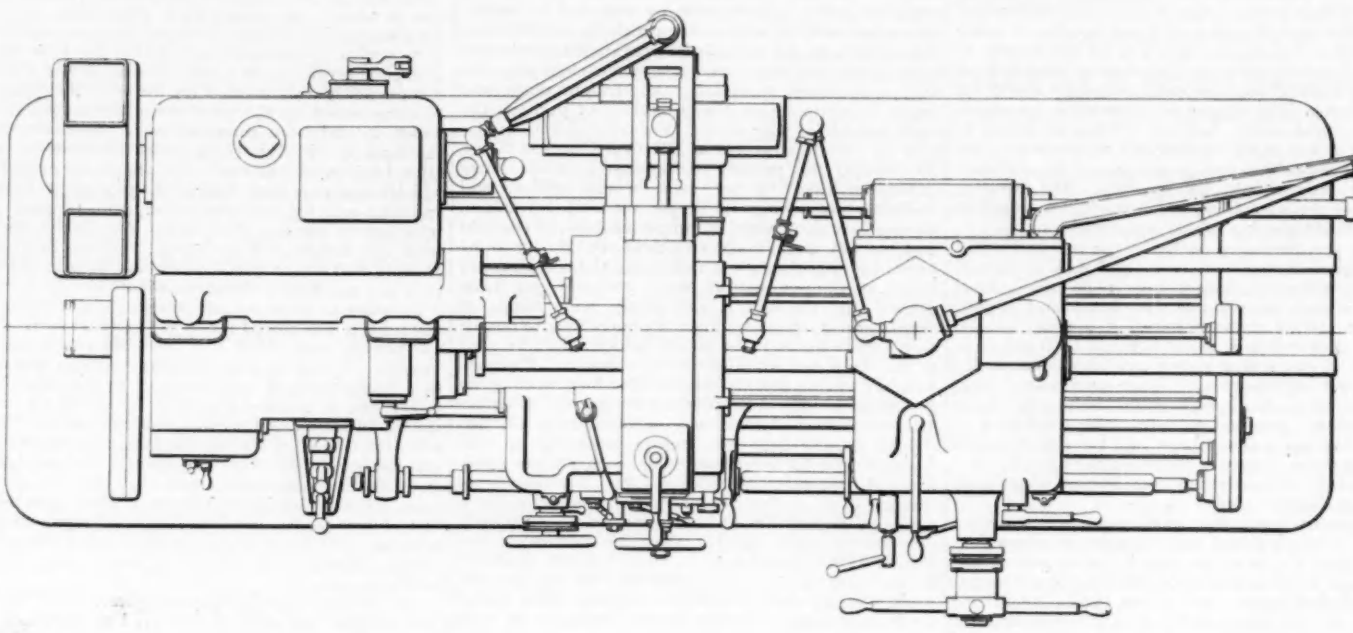
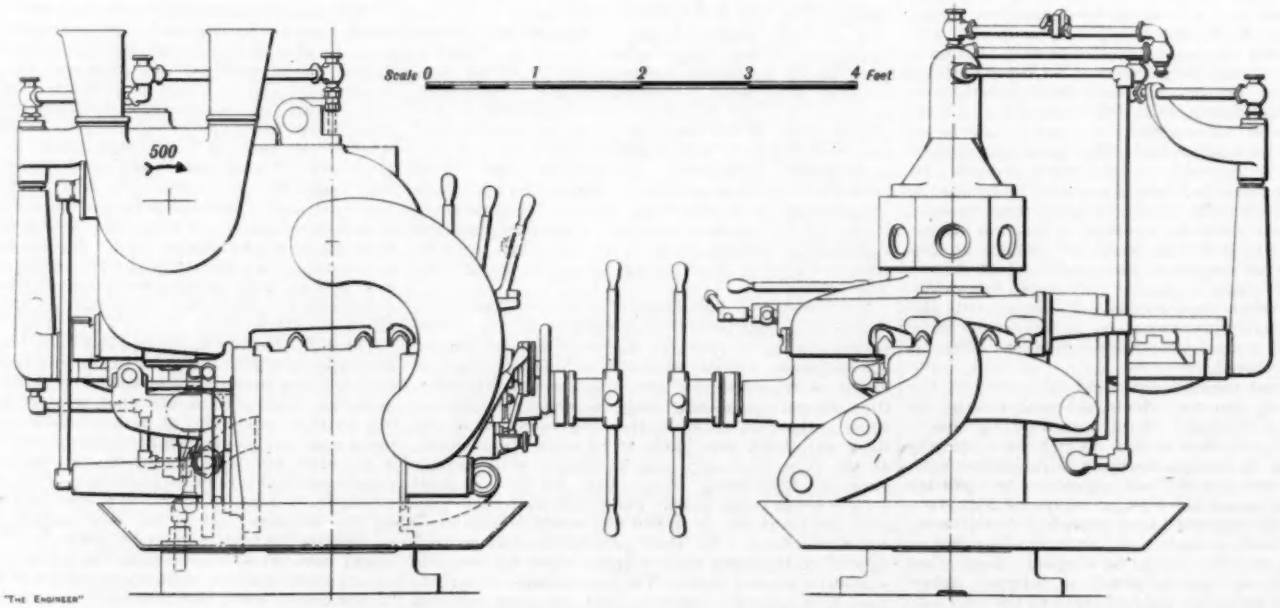
(*For description see opposite page.*)







"THE ENGINEER"

up prohibitive costs for re-tubing, the clock might be set back, and the operating costs of high-pressure plants would force users to look for something less costly in maintenance.

Mr. S. F. Dorey, in his reply, stated that, judging by the interesting discussion that had arisen, the paper had fulfilled one purpose for which it had been intended, namely, that of emphasising the very great need for co-ordination between the steel makers, the tube makers, the boilermakers, and the operating engineers in order to get some definite facts which would help them to draw up a specification and rules relative to tubes for high-pressure boilers. It seemed to him a matter for regret that while the Americans and Germans had already settled these questions for themselves, a satisfactory basis had not yet been established in this country. Whether the conclusions reached in America and Germany were satisfactory remained to be seen, although so far the results in service appeared to indicate that they were.

Many interesting and valuable facts and views had been brought to light in the discussion which would enhance the value of the paper. Several points which had been raised by various speakers could only be adequately dealt with in a written reply.

Mr. Marriner, who represented a firm which had made both land and marine boilers, had called special attention to the urgent necessity for a definite ruling regarding tube thicknesses, which question, it was to be hoped, would be brought to the notice of competent authorities.

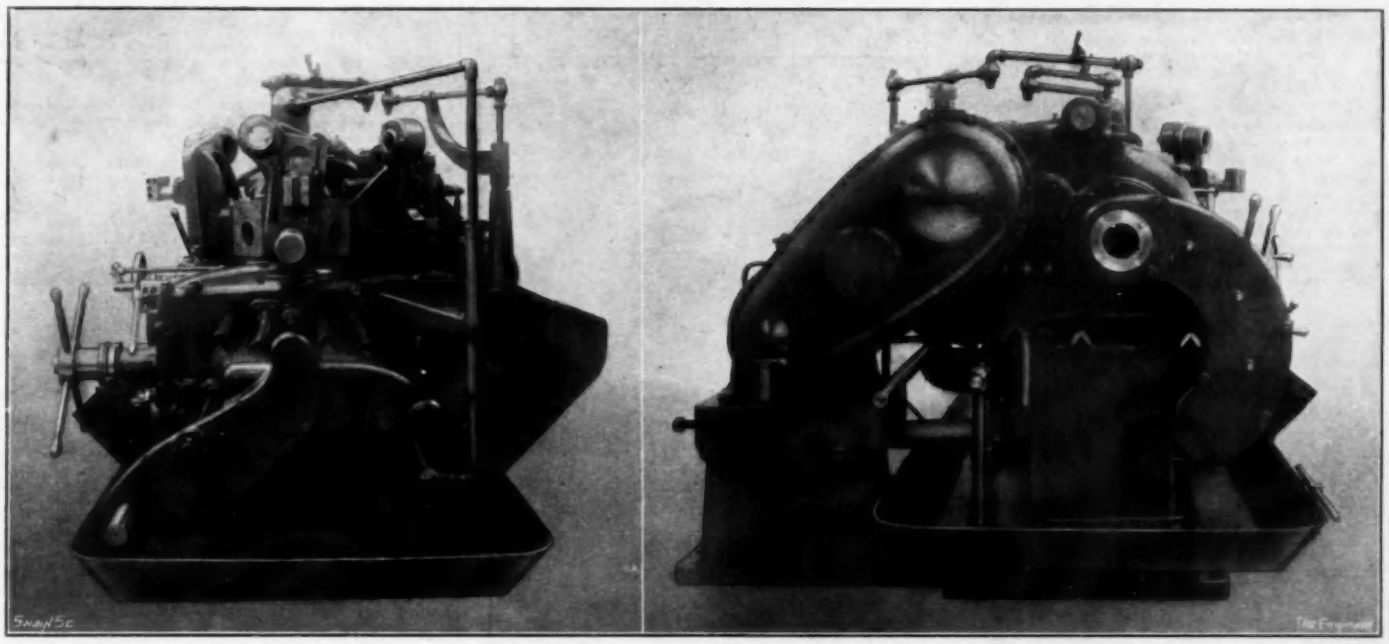
The series of tests on tubes referred to by him were of special value and they indicated the capabilities of tube material. Mr. Marriner's question with regard to the probable nature of the failure of a boiler tube which had been made too thick for the corresponding pressure and rating, needed careful thought, since it depended upon the position of the tube in relation to the fire and the degree of thickness in excess of the optimum value. With a very thick fire-row tube, bulging would take place on account of overheating, and that would interfere with the local circulation, thereby causing further overheating, with formation of scale on the inside and the final formation of blisters with ultimate perforation. Undoubtedly high stresses increased liability to corrosion, which was primarily due to the impossibility of producing a perfect finish to the tube surface.

That there was a diversity of opinion with regard to the maximum permissible percentages of sulphur and phosphorus was evident from the remarks of Messrs. Davy, Marsh and Geer. Those remarks indicated the need for co-operation between the steel maker and tube maker. The effect of increasing the carbon content on both the creep and the oxidation characteristics of mild steel tubes as mentioned by Mr. Humphrey Davey was of special interest to all concerned. Dr. Jenkins had raised a special point in connection with the mechanical testing of special steels which was worthy of careful consideration. Bearing in mind the improved properties under service conditions, it would be agreed that mechanical tests only slightly in excess of the work to which the material would be subjected during construction of a boiler should suffice, and that point would be satisfactorily met by the cold bending and the expanding tests.

The satisfactory annealing of the tubes, mentioned in the paper, to retard spheroidisation referred especially to proper normalising treatment, which, although it did not ultimately prevent spheroidisation, would retard its progress and incidentally retard the creep rate of the material.

He appreciated the remarks of Mr. Talbot and was glad to hear that the nickel-chromium-tungsten steel tubes were proving satisfactory in service at the conditions stated. The author's remarks regarding intergranular breakdown of that material referred to special (acid) tests, and in that respect perhaps his criticism had been too severe. The cost of that material was not definitely prohibitive if it was considered in the light of the subsequent saving in fuel derived from the increased steam temperature. He thought that in many cases first cost was allowed to influence the commercial man against the better judgment of the engineer, who often was not quite strong enough in backing his own convictions.

Mr. Marsh's comments regarding the respective merits of hot and cold-drawn tubes undoubtedly provided an interesting point for discussion. Mr. Geer had referred to the creep limit of copper-molybdenum steels. Certainly too much reliance should not be placed on short-time tests. The creep limit so determined might give some indication of the stresses the material might withstand satisfactorily for prolonged periods, but it gave no indication regarding rate of oxidation or permanence of structure. Referring to special alloy steels, he thought it would be agreed that all analyses should be checked for the buyer in order to show that the material was being consistently produced in accordance with the specification to assure that the special properties claimed for any material might be realised in service.



COMBINATION TURRET LATHE—TURRET END AND HEADSTOCK END VIEWS

A New Design of Combination Turret Lathe.

THE machine, known as the No. 10 combination turret lathe, which Alfred Herbert, Ltd., of Coventry, has recently produced, while it is undoubtedly a lineal descendant of the various patterns of combination turret lathes made by the firm, can justly be said to be new in design. It contains no new movements and substantially no new fitments, but in the manner of effecting the movements and in the detail design of its fitments, it possesses, almost at all points, a high degree of novelty. We recently had an opportunity of closely examining the design of the machine and of observing it at work and were greatly impressed not only by its high performance, but by the extreme care which had been devoted to the design of all its details from the smallest to the greatest.

The lathe has been constructed to take full advantage of the new tungsten carbide cutting metals of the "Widia" or "Carboloy" type. It is, however, equally suited to the use of high-speed steel, or other usual pattern of tools. It has, further, been designed not only to permit high accuracy of work to be achieved at the outset of its life, but to maintain that accuracy for a life at least 50 per cent. longer than the average useful existence of previous designs of machines of its class and size. Further, by the very generous use of ball and roller bearings, not only in the headstock, but throughout all its parts, the machine has a materially enhanced output, as measured in pounds of metal removed per horse-power expended in driving it and, in addition, is particularly light to operate. It is almost unnecessary to say that all the control handles are grouped in a manner making them very convenient to the attendant. It is not, however, superfluous to state that the provisions made to protect the machine from damage by faulty manipulation of the controls, &c., or the operator from injury by the moving parts, are exceptionally complete.

As some indication of the efficiency of the machine, it may be said that when tested against an ordinary machine of similar dimensions, the No. 10 combination turret lathe was found to be capable, without distress, of removing 29·4 per cent. more metal per horse-power-minute. Concerning its performance we can state that in our presence it was shown to be capable with a Widia-tipped tool of machining an 8¼in. diameter cast iron specimen piece with a feed $^3/_{32}$in. deep and 33 cuts per inch, with the work running at 364 r.p.m. These figures correspond to a cutting speed of 810ft. per minute. On the same material, and again using a Widia tool, the lathe reduced the 8¼in. diameter to 8in. with a feed of 55 cuts per inch at a cutting speed of 150ft. per minute.

General outline drawings of the lathe are reproduced on page 602, while herewith and on page 598, we give some photographic views illustrating its arrangement and some of its principal details.

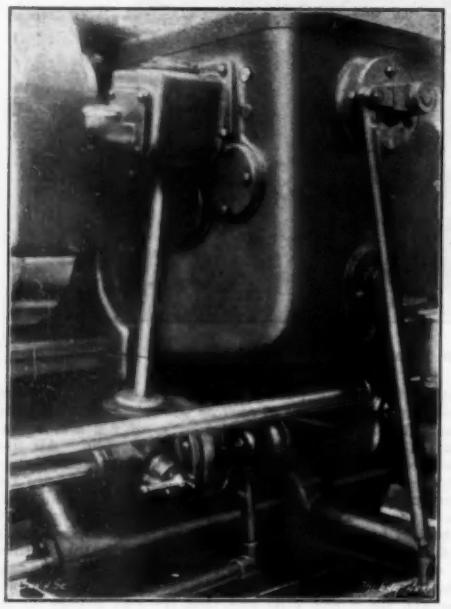
The construction of the bed is the first item to which attention should be directed. Apart from the attainment of strength and rigidity, exceptional pains have been taken to secure the free passage of the cuttings away from the tools on to the tray beneath the bed, and in particular to prevent them from lodging on the guiding surfaces supporting the saddle and the turret slide. As will be gathered from the overhead view on page 598, the central portion of the bed is almost completely open on the top side. It is, in fact, formed of nothing more than four guiding surfaces—two for the saddle and two for the turret slide—with three or four narrow stays running crosswise. These stays have their upper edges brought to the form of an inverted vee in order that cuttings may not lodge on them. The guiding surfaces for the saddle and turret slide are ground true. Looked at from the turret end of the bed and reading from left to right, the first and third surfaces are of narrow vee-section, and support the saddle. The second and fourth, of vee and square section respectively, support the turret slide. All four surfaces are completely protected from the ingress of chips and dirt of any kind by covers. These covers are not simply arched over the surfaces, but are bedded down on to them. There are eight covers altogether, two being attached to the forward and two to the rear edge of the saddle, and four similarly attached to the turret slide. It will be observed from the two end views on this page that the two covers on the rear edge of the saddle pass beneath the turret slide and that the two covers on the front edge of the turret slide pass beneath the saddle and also beneath the fixed headstock. The two covers on the front edge of the saddle also pass beneath the headstock. In this way the four surfaces are completely protected from end to end of the bed without any restriction being imposed on the movements of the saddle and the turret slide, either in unison or separately.

The construction of the headstock is the next point to which attention may be directed. It is impossible to explain it fully without reference to drawings of a more detailed nature than those which we are in a position to give. The drawings reproduced on page 602 show the lathe equipped for driving by means of a single belt pulley. The views on page 598 illustrate an alternative form of drive, namely, one making use of an electric motor and a completely enclosed silent chain. A notable feature of the design is the solidity of the main headstock casting. As shown in the two detail views given on page 604, the casting is not split, as is usual, at the level of the spindle bearings, but is carried up solidly on all four walls. The two end walls and the back wall are vertical. The front wall curves round the spindle and continues a short way across the top. An oblong opening on the top surface is the only break in the casting. It is closed by a simple cover plate. A small inspection cover, fastened by four captive screws, is provided on the main cover, as shown in the plan view on page 598. It might be thought that this design of casting would, in view of the manner in which the main spindle is enclosed by the walls, render the assembly of the headstock and its internal fittings a difficult and awkward process. An examination of the actual assembling of a headstock showed us that such was not the case. The main and other spindles are assembled by passing them horizontally into the casting and by threading their bearings, gear wheels and clutches on to them. This method of assembly is facilitated, if not, indeed, made possible, by the fact that all the bearings for the main and other spindles in the headstock are of the ball or roller type.

The gearing provided in the headstock gives sixteen

changes of spindle speed in the forward direction and eight changes in the reverse direction. These changes are effected by means of two gear wheels keyed to the main spindle, and groups of sliding gear wheels on the intermediate transmission shafts. Control over the starting, stopping and reversing of the spindle motion is secured through the agency of a high-speed multiple-disc clutch. In the accompanying engraving, illustrating the front side of the headstock, the means provided for selecting the speeds are shown. They consist, in the first place, of three coaxial levers, each of which has two positions—to the left or to the right. Eight settings of these levers are possible. If the operator starts the machine by moving inwards the lever shown in his left hand, he will obtain one of a series of eight forward speeds—series A, as we may call it. If he starts the machine by moving the starting lever forwards, he will obtain one of another series of eight forward speeds—series B. If the small lever shown above the three coaxial levers is thrown over from left to right, one of a series of eight reverse speeds will be obtained by moving the starting lever inwards. If, however, the starting lever is moved outwards the operator will not obtain a second series of reverse speeds, but will again get the series B of forward speeds. The forward speeds with the main shaft running at 500 r.p.m. range from 11 to 593 r.p.m. and the reverse speeds from 11 to 424 r.p.m. The starting lever is mounted on a shaft which runs down the front of the bed and which carries two duplicate starting levers, one at the saddle and one at the turret.

The bottom of the headstock casting forms an oil tank, from which oil is drawn by a pump and delivered through a sight glass and filter to a tray at the top of the headstock. From this tray the oil flows away through pipes to the internal mechanism of the headstock. Cutting lubricant is supplied by a pump driven from the first motion shaft in the headstock through an inclined shaft passing externally across the chuck end of the headstock, as shown in the engraving given below. A control is provided on this pump to stop the flow when lubricant is not required. The considerable amount of momentum present in the rotating parts inside the headstock combined with the easy running resulting from the very libera use of ball and roller bearings would cause the main spindle to continue rotating some time after the driving clutch had been slipped. This unwanted motion is checked by means of a brake, which is automatically applied to or



REAR VIEW OF HEADSTOCK

removed from the main spindle when the machine is stopped or started. On top of the headstock a long, very rigid bracket is mounted to carry an overhead support bar with which guide blocks on the turret co-operate.

From the rear end of the main spindle a train of enclosed gear wheels conducts motion to a three-speed gear-box through which chasing feed is applied to the saddle. This gear-box drives a short lead screw in front of the bed. By changing this lead screw and its nut, the pitch of the screw to be chased can be varied. Each lead screw can be used to chase a thread of its own pitch or through the changes provided in the gear-box a thread of half or quarter its pitch. A reversing lever is fitted on the gear-box to enable either right or left-hand threads to be cut. A set of seven lead screws and nuts enables all the usual pitches from 4 to 28 per inch to be cut. The train of wheels connecting the spindle with the chasing gear-box also drives a spline shaft from which reversible automatic sliding and surfacing feeds are communicated to the tools of the saddle. The selection, engagement, and reversal of these feeds are controlled by means of levers on the saddle apron. There are sixteen feeds in either direction, the sliding feeds ranging from 6 to 240 cuts per inch, and the surfacing from 10 to 400.

The cross slide of the saddle is a steel forging. It is fitted with a square turret at the front and a tool post at the rear. A swivelling guide at the rear of the slide permits either external or internal tapers to be turned. It is also available for the machining of tapered threads. Both motions of the saddle tools are fitted with automatic and dead stops. For the sliding motion the stops are carried on a hexagonal bar at the front of the bed. For the surfacing motion they are carried on a square bar running along the rear edge of the saddle and protected from chips by a light hinged cover.

The turret slide can be moved rapidly along the bed in either direction by power motion transmitted from the headstock by a constant speed shaft to a supplementary apron at the rear of the turret slide. This motion is controlled from a lever at the front of the slide. The power feeds to the turret are obtained through change gearing in the apron at the front of the slide. They are sixteen in number and range from 6 to 240 cuts per inch. These feeds are the same in number and range as the sliding feeds to the saddle, but the two sets are completely independent, the selection made from one set being quite unhampered by the selection made from the other. Provision is naturally made to prevent the possibility of the rapid power traverse and the power feed to the turret slide being engaged simultaneously. An additional safety precaution is to be noted in connection with the star handle provided for moving the turret along the bed by hand. There is a well-known danger resident in this handle if it is allowed to rotate when the slide is being moved by the rapid traverse or by one of the higher power feeds. It is usual to provide the handle with clutch teeth and a spring to disengage it from its shaft. This arrangement necessitates for the movement of the turret slide by hand a combined inward and tangential thrust on the handle. In the lathe illustrated no inward thrust is required. Mechanism is provided whereby the handle is normally engaged with its shaft except when the power traverse or power feed motion is applied to the turret, at which times the handle is automatically disengaged from its shaft.

The feed to the turret slide is governed by six stops on a hexagonal bar mounted in front of the bed in line with the similar bar provided to govern the sliding feed of the saddle. The hexagonal bar for the turret is coupled by

HEADSTOCK FROM THE FRONT

gearing to the turret in such a way as to rotate when the turret is rotated, and therefore to present a different stop for each of the six faces on the turret. The two hexagonal stop bars can be adjusted simultaneously and to the same extent in the direction of their length. This adjustment, affecting as it does in unison the extent of the sliding feed of the saddle and the feed of the turret, is of value in certain circumstances, as, for example, when there is a variation in the rough lengths of the articles being machined.

Power rotation to the turret is not fitted because of the danger to the operator involved in the possibility of his being struck by long boring bars or other tools carried on the turret. Provision has, however, been made to relieve the operator of fatigue by making the turret exceptionally light to rotate by hand. When the clamping lever is slackened, the turret is automatically raised from its bearing on the slide and its weight is taken on a ball thrust bearing. It can then be turned by a light pressure from the fingers, even when the tools mounted on it are such as to make it considerably out of balance. When the turret has been located it is pulled solidly down on its bearing by the action of the clamping lever.

The system provided for delivering a supply of cutting lubricant to the tools constitutes a conspicuous feature of the design. The pump, as has already been remarked, is driven from the first motion or constant-speed shaft in the headstock by means of an external inclined shaft. It delivers its output to a telescopic pipe running along the rear of the bed. A supply is taken from this pipe to a jointed delivery pipe carried by a standard and arm mounted on the rear end of the saddle slide. The telescopic pipe is continued past the saddle and well beyond the turret slide. A rising pipe supported from the turret slide by a bracket which is sufficiently long to provide the clearance required by the longest boring bar conducts the cutting lubricant through a horizontal pipe to a central dome over the turret. From this dome the supply is taken through a jointed pipe to the turret tool in action. Provision is made whereby the fluid from the dome can be delivered to the point of the tool, not through the jointed pipe, but internally through a bore-hole formed along the tool.

We have already mentioned the extensive use made of ball and roller bearings in the headstock. It should be added that elsewhere throughout the machine similar bearings are introduced at all points where their use is convenient and desirable. Messrs. Herbert have had lengthy experience in their own shops with ball and roller bearings in machine tools, and assure us that the absence of wear in the bearings renders it possible to dispense with any provision for adjusting them. The use of these bearings is undoubtedly a considerable factor in the long and accurate life claimed for the machine which we have described. Another important factor in that connection is the thorough system of lubrication which is adopted. In addition to the pump supplying oil to the mechanism inside the headstock, there is a separate oil pump in the chasing gear-box, another one in the saddle apron, and yet another one in the apron of the turret slide.

The machine is capable of swinging a diameter of 20¼in. over the covers of the bed and of 12½in. over the cross slide of the saddle. It can admit a maximum length of 54in. between the flange of the headstock spindle and the face of the turret. With the standard leading screw provided, it can chase a thread up to 15in. in length. For medium work it is driven by a 10 horse-power motor. A much larger machine of the same general design is now in course of manufacture.

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The Coefficients of Heat Transfer from Tube to Water.*

By ALBERT EAGLE, B.Sc., and R. M. FERGUSON, M.Sc., Associate Member.

Introduction.—The transfer of heat from one fluid to another across an intervening metal plate is of such importance to the engineer concerned with the design and operation of apparatus such as surface condensers, feed-water heaters, and similar auxiliaries, that the British Electrical and Allied Industries Research Association formed a committee of prominent engineers, experienced in condenser design, with the present authors as investigators, to inquire into this problem and the present state of knowledge on the subject.

An exhaustive survey was first made of all relevant published articles on heat transfer, but it was found impossible to deduce any general rule by which one could predict what the coefficient of heat transfer would be under any given conditions. Various independent experiments had been carried out, but the conclusions from the different sources could not be made to harmonise. Many experiments had been made on complete surface condensers from which an overall coefficient of heat transfer had been derived and attempts made to indicate how the coefficient depended upon certain prevailing variable conditions. The results of such experiments can only be regarded as having a very limited application, however, and apply only to the particular type of condenser on which the experiments were carried out.

It is impossible to give values for an overall coefficient of heat transfer in a condenser which are applicable to any definite known conditions because of the large number of variables involved, and the wide ranges which many of these variables have throughout a complete condenser both on the steam and water sides. To reduce the number of variables several experimenters have carried out tests on a single tube, steam-heated on the outside. By so doing the water can be fed into the tube at a definite temperature and speed, but the corresponding appropriate conditions are not obtained, on the steam side, where, as has always been the case, the steam passes axially along the outside of the tube. The coefficient of heat transfer obtained on the steam side of these experiments cannot be considered as having any applicability to ordinary condensers, as the conditions are totally different; also, on the water side, there is great difficulty in knowing both the amount of heat taken up by the water in any portion of the tube and the water temperature at any distance along it.

For these and other reasons it was decided to conduct a new research with the object of determining as fully as possible the way in which the coefficient of heat transfer varies with the physical properties of the fluids employed. The research in the first instance was confined to determining the phenomena on the water side of a condenser tube. In this investigation several important factors were brought to light, and the committee, with the consent of the Association, decided to bring these to the attention of the members of this Institution and the general body of mechanical engineers.

For this investigation it was decided to heat the tube electrically by passing through it a low-tension A.C. By this means the rate of heat flow into the water is under precise control and can be varied exactly as desired. Not only this, but the heat put into the water in any given length of the tube is known, being equal—save for the small external heat loss—to the C^2R heat generated in that portion, using the usual notation. Moreover, the outside of the tube being dry, the temperature of this surface can be more easily obtained by thermo-couples than when these have to be protected from the steam by another tube, by varnish or other means.

With steam-heating on the outside of the tube the insertion of thermo-couples into the water is necessary to obtain the water temperatures so as to determine the temperature difference between the tube and the water; but the authors found that the insertion of such thermo-couples produced a considerable increase in the turbulent motion of the water, so that the conditions prevailing around the couple must be different from those in an ordinary smooth tube. Again, the thermo-couple readings varied considerably with the position of the couple over the cross section, so that it was impossible to know just where the couple should be placed, and to insert a large number of thermo-couples at one cross section, and take their mean reading would be absurd. Yet with steam-heating there is no means of knowing how much heat has been supplied to the water up to any cross section save by such thermo-couples. Moreover, each thermo-couple in the water was found to cause a drop of hydrostatic head equivalent to that of about 2in. of tube length—a serious disturbance, since one of the objects of the research was to determine the loss of head during actual heat transfer.

Fortunately, the adoption of electric heating quite obviated the necessity for any thermo-couples in the water. The electric heat put into the water up to any cross section could be calculated with precision and the temperature of the water was accordingly taken as the temperature calculated from the electric input. This mean temperature of the water is what an engineer always thinks as of the water temperature. But it is not the same as the temperature of the water along the axis of the tube, which might be obtained on a thermo-couple. It is, obviously, necessary to define in some manner what one means by the water temperature at any cross section before one can define a coefficient of heat transfer, since the value obtained for the coefficient depends upon the temperature that is taken for the water.

Even on the water side alone the number of variables is considerable. There is the tube diameter, the water velocity, the water temperature, and the heat-flow rate, not to mention two other variables that may come in. First, there is the irregular turbulence near the commencement of the tube, and second, there is the variation of the coefficient of heat transfer at the commencement of the heated portion of the tube, which occurs before sufficient heat has been put into the water to produce the limiting, or equilibrium distribution, of temperature over the cross section. These last two sources of complication were eliminated in the present experiments; but even so, it is not till values of the coefficient of heat transfer K have been obtained over a wide range of tube diameters, water velocities, water temperatures, and heat-flow rates, that any theoretical conclusions as to the way in which K varies with the physical conditions present can be deduced or formulated.

Description of the Apparatus.—The arrangement of the ¾in. diameter tube when under test will be seen from the sketch in Fig. 1. The tube was 15ft. long, but only a length of 6ft. 3in. near the outlet end was electrically heated. This heated length varied for tubes of different diameters and was partly dependent upon the electrical resistance of the tube, the electric power available, and the heat flow rate desired. A small turbo-alternator was specially operated for these tests. The alternator current was passed through the primary of a step-down transformer with an electrolytic rheostat in series for purposes of regulation. The large low-voltage current from the secondary was fed into the two brass lugs L_1 and L_2 soldered on the tube through six, or sometimes twelve, copper straps of 1¼in. by ⅛in. section. These leads were kept only a few inches from the tube to prevent a large inductive load. One set of leads was passed through a bus-bar transformer which was used to measure the current.

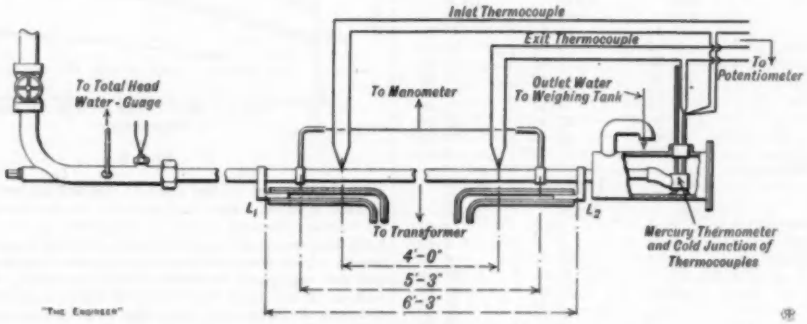


FIG. 1—ARRANGEMENT OF EXPERIMENTAL APPARATUS

Two copper-constantan thermo-couples were soldered to the heated portion of the tube at a distance of 13½in. from each of the brass lugs. The "cold junctions" of these thermo-couples were immersed in oil in thin glass tubes and were placed in the exit water, close beside a mercury thermometer which could be read to an accuracy of 0·1 deg. Fah. The two thermo-couple wires emerged separately, about ⅛in. apart, from a small blob of solder on the tube. They were laid down in a direction parallel to the tube for about 1in., but insulated from it by a thin flake of mica. Another flake was laid over them, and—to prevent any air cooling of the wires at the junctions—the whole was bound with several layers of asbestos cord. After this point the thermo-couple wires were twisted together and led away at right angles from the tube, to avoid, as much as possible, the induced alternating voltage in the thermo-couple circuit brought about by the large alternating magnetic field round the tube.

An additional thermo-couple was used to measure directly the temperature rise of the water between the inlet and the outlet. This was fitted as a check to see whether the C^2R electrical heat supplied agreed with the heat given by the temperature rise of the water. Such was found to be the case within experimental limits and the readings of this thermo-couple were discarded since the electrical measurement of the heat supplied was more precise, the current being maintained constant by an observer, who, by hand regulation of the rheostat, kept the bus-bar ammeter pointer on a definite division of the scale.

Town water was supplied to an elevated galvanised iron tank, the water being kept approximately level by a ball valve. This tank gave a total head of about 18ft. above the condenser tube. The water in the tank could be heated to any desired temperature by means of a number of steam jets. A mechanically driven stirrer and baffles were added to ensure that only thoroughly mixed water was drawn into the exit pipe. The water then passed through a 2in. descending pipe and a control valve to the condenser tube. A by-pass pipe, with a small stop valve, was fitted in order to adjust accurately the flow at low velocities. The extra turbulence at the entrance to the condenser tube was prevented from affecting the heat transfer by the water having to flow through a length of over 7ft. of the tube before reaching the heated portion.

The loss of hydrostatic head of the water during heat transfer, was obtained over a length of 5ft. 3in. of the heated portion. At a distance of 6in. from each of the brass lugs L_1 and L_2 four holes ⅛in. diameter, at right angles to each other, were drilled through the tube. Two small grooved sleeves were then soldered over these holes and connected to water manometers in the usual way. Another manometer was inserted near the inlet to the tube to facilitate the control and adjustment of the water velocity.

The tube extended for about a foot beyond the exit heating lug to allow the water to mix thoroughly before its temperature was observed. With the 1in. and the 1¼in. tubes, this distance was found to be insufficient, so a spiral wire, about ¼in. diameter, was fitted into the tube for a length of about 8in. to facilitate mixing the water before it flowed over the mercury thermometer and the "cold junctions" of the thermo-couples. These were placed just beyond the end of the tube, in the water box surrounding the last 10in. or so of the tube. A side exit from this box enabled the water to run to waste or into a measuring tank. It was found that for the lower velocities in the ¾in. and ⅞in. diameter tubes, the volume of water was insufficient to give adequate mixing in the water box, so a pipe bend with a short wide vertical limb, into which the thermometer and thermo-couple cold junctions could be placed, was fitted over the end of the experimental condenser tube. This was virtually the same as employing a much smaller water box.

Tube Measurement and Calibrations.—All the tubes were measured externally and found to be reasonably round and uniform throughout their length. The mean internal diameter of the tubes was found by weighing them when corked up empty and dry and again when filled with water. Allowance was made for the density of the water corresponding to its temperature and for the buoyancy of the air.

As the outside diameter of the tubes was so uniform it was at first assumed that the same would apply to the internal diameters. It was discovered later than the internal diameters were, in fact, conical, and the non-uniformity of the metallic cross section was easily verified by balancing the tube over a knife edge, when a 15ft. tube would balance about a point as much as 1¼in. away from its centre of length. The variation of metallic cross section was more accurately ascertained by determining the electrical resistance per foot at different positions along the tube. The results obtained in this manner agreed very closely with those given by the simple knife-edge test. This change in diameter necessitated in some cases a correction of about 3 per cent. on the deduced coefficient of heat transfer.

As the heat input was given by C^2R, the accurate determination of the electrical resistance of the tube at different temperatures was important. This resistance was determined—before the lugs had been connected to the copper straps—by passing a current of about 1 ampère through the tube and through a known standard low resistance—0·002063 ohms—in series with it. The two potential drops were then compared on the potentiometer used with the thermo-couples. The tube resistance was found at different temperatures, by passing water through it at the desired temperature and at a speed of about 5ft. per second. From these observations a curve was constructed giving the resistance of the tube from about 45 deg. to 190 deg. Fah. Also by comparing the potential drops over successive foot lengths of tube, it was possible to determine the actual resistance per foot length at the two thermo-couples, or, in other words, to determine the percentage correction to be applied to the resistance curve to correct for the conicality of the internal bore.

The thermo-couple E.M.F.'s were measured on a potentiometer in the usual way, a Weston Normal Cell being used to check the constancy of the potential gradient down the potentiometer wire. About 10 cm. of wire corresponded to 1 deg. Fah. The thermo-couples were calibrated after soldering on the tube. For this purpose water at a known temperature was passed through the tube at a good speed, the temperature of the water being given by the mercury thermometer in the water box. The other junctions of the thermo-couples were placed either in ice or in a thermos flask which contained hot water or oil, at various temperatures up to about 230 deg. Fah. Another mercury thermometer, which had been compared with the first, gave the temperature of the junctions in the flask. Widely different temperature differences, never less than 40 deg. Fah, were employed in this calibration. Sometimes the tube junctions were hotter and sometimes colder than the other junctions. The length of the potentiometer wire divided by the temperature difference was plotted against the mean temperature of the junctions. The calibration was carried out over a range of mean temperatures from about 50 deg. to 190 deg. Fah.

A very suitable potentiometer was made by modifying the connections in a Callendar and Griffiths bridge intended for use with their platinum resistance thermometers. The position of the "electrical end" of the bridge wire was determined and the coils calibrated in terms of the bridge wire.

The bus-bar transformer, together with its ammeter, was calibrated directly against a Kelvin current balance, and the standard low resistance of 0·002063 ohms was also calibrated against certified standards.

The heat loss from the outer surface of the tube was determined by passing a small A.C. through it when dry, and measuring the temperature attained by the tube from the thermo-couple readings. A temperature rise of about 100 deg. Fah. was employed in this case and the heat loss was taken as being proportional to this temperature difference. It will be seen below that the only external heat loss which need be taken into account is the extra heat loss due to the temperature rise of the tube caused by the electric heating. The heat loss due to hot inlet water flowing through the tube is compensated for by the method of working.

Experimental Observations and Calculations.—When carrying out a series of tests it was usual to heat the water in the upper tank to the required inlet temperature. During this preliminary stage the water was allowed to flow to waste through a by-pass tube at about the same rate as was intended when flowing through the test tube. This prevented the dirtying of the tube surface before the actual heat flow test commenced. When the water temperature was nearly steady at its desired value, the water was diverted through the tube and the stop valve adjusted till the quantity passing in five minutes showed the desired velocity. The manometer near the stop valve enabled this velocity to be maintained at its correct value. The weight of the water corresponding to any given velocity was taken as that which the weight would be if the water

* Institution of Mechanical Engineers, being report Ref. H/T16 received from the British Electrical and Allied Industries Research Association.

was at its maximum density. Thus the same weight was taken whether the water in the tube was cold or hot. What is here taken as the velocity is not the actual physical velocity v, but ϱv, where ϱ is the specific gravity. Theoretically ϱv is preferable to v as a variable, and in practice an engineer is always more interested in the weight of water passing through a tube than in its volume, which, for a given quantity of water, varies with the temperature. Accordingly, in this investigation, which deals with water only, ϱv has been termed the "nominal" velocity. Several experimenters have termed ϱv the mass velocity, since it is given by the weight divided by the product of the cross section and the time.

The velocities most generally employed were 2ft., 3ft., 5ft., 8ft., and 11ft. per second. Having obtained the desired velocity, the water weight, water temperature, and readings on both manometers were recorded. The thermo-couple readings were also taken and these readings were used as zero points on the potentiometer wire. In this way two or three small errors referred to later were eliminated. For each condition of water flow—given by velocity and temperature—tests were made with three definite values of the current, which were chosen to give heat flow rates of about 4000, 12,000, and 20,000 B.Th.U. per square foot per hour, except in the case of the 1½in. tube, when the heat flow rates of 4000, 8000 and 12,000 were employed, since the power available did not permit of higher rates being reached. As the bus-bar transformer had two equal windings which were changed from parallel to series between the first and second heat flow rates, heat flow rates in the ratio of $1 : 3 : 5$ gave ammeter readings in the ratio of $2 : \sqrt{3} : \sqrt{5}$, *i.e.*, about $8 : 7 : 9$.

If R is the electrical resistance of the heated portion of the tube at its mean temperature, C the current and S the internal area of the heated surface in square feet, the heat flow rate is $3{\cdot}412\ C^2\ R/S$ B.Th.U. per square foot per hour.

Whenever heat was switched on, it was noticeable that the water heights in the manometers fell slightly and in most cases the water weight slightly increased. This was more pronounced at low water temperatures when the stop valve had to be adjusted to reduce the flow and fresh weighings taken till the correct flow was again obtained.

TABLE I.—*Particulars of a Typical Experiment with a ¾in. Tube at a Water Velocity of 8ft. per Second.*

A length of 178·9in. of the tube held 2·157 lb. of water at 60 deg. Fah., giving a mean internal diameter of 0·6532in., an internal heated surface of 1·0675 square feet, and a flow of 347·5 lb. in five minutes, corresponding to a velocity of 8ft. per second.

1.	Heating current in ampères	840	1,458	1,876
2.	Weight of water in five minutes, lb.	349	350	348
3.	Temperature of outlet water, deg. Fah.	39·2	41·2	43·2
4*a*.	Temperature rise on inlet thermo-couple, deg. Fah.	2·12	6·20	10·06
4*b*.	Temperature rise on outlet thermo-couple, deg. Fah.	2·73	7·98	12·91
5*a*.	Temperature of outside tube surface at inlet thermo-couple, deg. Fah.	41·32	47·40	53·26
5*b*.	Temperature of outside tube surface at outlet thermo-couple, deg. Fah.	41·93	49·18	56·11
6.	Allowed temperature drop through tube wall, deg. Fah.	0·12	0·36	0·60
7*a*.	Temperature of inside tube surface at inlet thermo-couple	41·20	47·04	52·66
7*b*.	Temperature of inside tube surface at outlet thermo-couple, deg. Fah.	41·81	48·82	55·51
8.	Resistance of heated portion, milli-ohms	1·769	1·779	1·789
9.	C^2 R heat flow, B.Th.U. per square foot per hour (1 watt = 3·412 B.Th.U. per hour)	3,990	12,095	20,130
10.	Extra external heat loss, B.Th.U. per square foot per hour	10	25	40
11.	Net heat flow rate, H	3,980	12,070	20,090
12.	Calculated water temperature rise from electric heat, deg. Fah.	1·01	3·07	5·14
13*a*.	Water temperature at inlet thermo-couple below outlet water, deg. Fah.	0·83	2·52	4·21
13*b*.	Water temperature at outlet thermo-couple below outlet water, deg. Fah.	0·18	0·55	0·93
14*a*.	Water temperature at inlet thermo-couple, deg. Fah.	38·37	38·68	38·99
14*b*.	Water temperature at outlet thermo-couple, deg. Fah.	39·02	40·65	42·27
15*a*.	Temperature difference tube water at inlet thermo-couple, deg. Fah.	2·83	8·36	13·67
15*b*.	Temperature difference tube water at outlet thermo-couple, deg. Fah.	2·79	8·17	13·24
16*a*.	Item (15*a*) corrected for water velocity, $= \Delta_i \theta$	2·84	8·41	13·69
16*b*.	Item (15*b*) corrected for water velocity, $= \Delta_o \theta$	2·80	8·22	13·26
	Both the above sets of values for $\Delta\theta$, when smoothed graphically by plotting against H, so as to vanish when $H = \theta$, remained unaltered.			
17*a*.	K at inlet thermo-couple $= H \div \Delta_i \theta$	1,402	1,436	1,467
17*b*.	K at outlet thermo-couple $= H \div \Delta_o \theta$	1,422	1,468	1,514
18*a*.	Item (17*a*) corrected for conicality (+1·75 per cent.)	1,427	1,461	1,492
18*b*.	Item (17*b*) corrected for conicality (−2·1 per cent.)	1,392	1,438	1,483

It was impracticable, however, always to work with the exact water velocity desired, so it was endeavoured to get it correct to within 1 per cent. and to apply a correction to the coefficients of heat transfer obtained, these being taken as varying as the 0·8 power of the velocity.

Having obtained steady conditions of the desired values with the electric heat switched on, the weight of water flowing through the tube in five minutes—or ten minutes for the ½in. tube at low velocities—was measured, and during this period at least three observations of each of the thermo-couple readings, the water gauges and the outlet thermometer were taken. If these observations were sufficiently steady, the same work was repeated with the second or third rate of heat flow. If not, the experiment was repeated again when steadier conditions could be realised.

Preliminary Results and the Effect of Dirt.—The effect of dirt on the inner surface of the tube was well shown during the early period of the tests. A number of tests had been carried out with various water velocities and inlet temperatures and the coefficients of heat transfer calculated for the conditions at the thermo-couples. These were plotted against the water temperature at the thermo-couples, and as the plotted points were somewhat irregular a number of the tests were repeated, when it was found that consistently lower values were obtained, the difference being greatest when comparison was made with the earliest tests. It was found that after the tube had been in use for about fifty hours the values of the coefficient of heat transfer at 7ft. per second had dropped as much as 15½ per cent., while the manometer showed that the hydrostatic resistance over the 5ft. 3in. length had increased by 9 per cent. Similar results were obtained at a velocity of 4ft. per second.

The tube was inspected by drawing a flash-light bulb through it, and it was seen that the surface was covered with a fine brown deposit largely of an iron hydroxide from the various pipes of the supply system. This difficulty was overcome subsequently by drawing a well-rinsed wash-leather plug two or three times through the tube after every two or three hours of use and by cleaning out the supply tank occasionally.

While the 1in. tube was under test an experiment was made to see if the wash-leather plug was really effective in thoroughly cleaning the surface. A cotton waste plug moistened with dilute hydrochloric acid was pulled through the tube several times. Two tests with cold water and the same velocity were made just before and after this acid cleaning, but no increase in the coefficient of heat transfer was obtained. In fact, the second test gave a value of 0·75 per cent. lower, to which small difference no importance should be attached, as it was within the margin of experimental error. But it was taken as indicating that the cleaning by the wash-leather plug was sufficiently effective. No gradual decrease in the coefficients has been found in any of the tubes since the practice of regular cleaning was introduced.

A number of tests was carried out at a speed of 1ft. per second on the ¾in. tube, with inlet water temperatures of 60 deg. Fah. and 90 deg. Fah. The deduced coefficient K increased with the heat flow rate, as in other cases, but when the values were plotted against the corresponding water temperatures it was found that a single curve would pass approximately through all the points, the increase in K with heat flow being little more than that due to the higher water temperature which was obtained by the higher heat flow rate. Tests were not taken systematically at a velocity of 1ft. per second, but such tests as were made were in agreement with the other results. In one case, when five heat flow rates in multiples of 5000 B.Th.U. square foot per hour, were tried with the temperature of the inlet water at 140 deg. Fah., the experiment proceeded satisfactorily until the highest current was passed through the tube; then the observations at the exit thermo-couple became very unsteady. The exit water temperature was now 185 deg. Fah., and when the test was worked out it was found that the exit thermo-couple reading indicated a tube temperature of 220 deg. Fah., the water temperature at this section of the tube being 179 deg. Fah. A tube temperature of 220 deg. Fah. must cause the rapid formation of steam at the tube wall, and thus break up the viscous film. The effect of this was seen in the deduced value of K; in the last case it was 25 per cent. greater than that for the preceding rate of heat flow, though previously the increase in K had been only 5 per cent. between each rate of heat flow.

A Sample Test.—It is unnecessary to give the detailed observations and calculations of all the experiments carried out; but an idea of the magnitude of the quantities measured and the method of reducing the experimental data is best acquired by studying a typical test. The test detailed in Table I. was carried out on a ¾in. diameter tube having a mean bore of 0·653in.; the actual bore at the inlet thermo-couple was 0·6525in., and at the outlet thermo-couple—48in. distant—0·649in. The tube had been put down at random before its conicality was discovered, and the same was the case with the other tubes, so that in some cases the flow was in a converging tube and in other cases a diverging tube. This non-uniformity of bore required three corrections to be made to the coefficients of heat transfer that had previously been calculated on the assumption that the tube was uniform. First, the resistance per unit length at a thermo-couple was different from the mean value; this directly affected the C^2 R heat generation and was the largest correction. Second and third, both the water velocity and the surface per unit length through which the heat was flowing were changed slightly by the variation of diameter. The effect of these three corrections in the case of the present tube was to increase the coefficients found at the inlet thermo-couple by 1·75 per cent. and to reduce those given at the outlet thermo-couple by 2·1 per cent.

It must also be pointed out that since the heat was generated throughout the material of the tube, the temperature drop through the tube wall was only half what it would have been for the same rate of heat flow had the outside of the tube been heated with steam.

The K's in Table I. are the values at the water temperature given in items (14*a*) and (14*b*) respectively. Extrapolating them to a zero or infinitesimal rate of heat flow gives $K_o = 1410$ at a water temperature of 38·2 deg. Fah. from the inlet thermo-couple; and $K_o = 1369$ at the same water temperature from the outlet thermo-couple, the former being 3 per cent. in excess of the latter, owing to the fact, dealt with more fully below, that a definite coefficient of heat transfer cannot be obtained till sufficient heat has been put into the water to establish sensibly the limiting temperature distribution over the cross section. The distance required for this purpose is of the order of the length in which the loss of head is equal to the velocity head; that is to say, about thirty to forty diameters. Before this the observed coefficients are greater than their limiting values.

Consideration of Some Minor Errors.—A few minor errors must be mentioned just to show that they are inappreciable. (1) The unequal distribution of the A.C. over the cross section was considered and it was found to render the heat production only about 1 part in 80,000 greater than that given by C^2 R. (2) The longitudinal flow of heat down the tube was estimated and found likewise to be completely negligible, and the same was the case with any possible differential longitudinal flow which would at once become a transverse flow into the water. (3) The variation of heat production due to the varying resistance per unit length caused by the temperature gradient along the tube was also found to be negligible. (4) The effect of the thermal conductivity from or into the copper straps *viâ* the lugs was eliminated by taking the thermo-couple readings just before switching on the heating circuit, and using these—small—readings as the thermo-couple zeros. This did not eliminate the conduction into the tube of heat which was generated in the leads; in some experiments this conduction could be detected with the largest heat flow rate, and was indicated by a slow creep of the thermo-couple reading. Such experiments were discarded and repeated.

Test Results.—The results of the tests on a ¾in. diameter tube are shown in Fig. 2. The points in this diagram give the coefficients of heat transfer at the outlet thermo-couple for the three heat flow rates of approximately

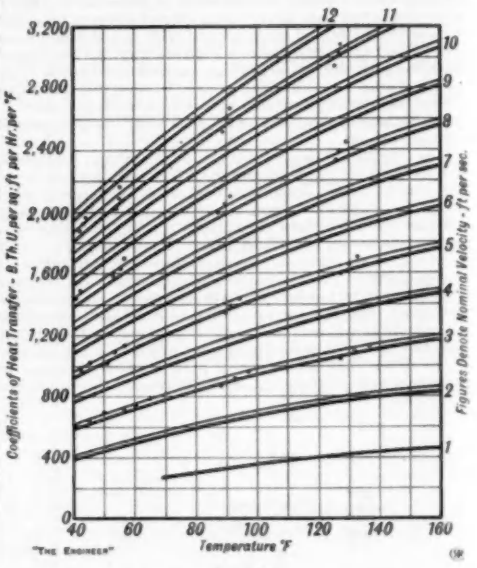


FIG. 2

4000, 12,000 and 20,000 B.Th.U. per square foot per hour, plotted against water temperature at the thermo-couple, for various nominal velocities, while the curves are for the heat flow rates of 0 and 20,000, as deduced from the tables below, which combine the whole of the experimental tests and are applicable to tubes of any diameter. The actual values of the heat flow rates differed somewhat in the different experiments, since the tube resistance increased with its temperature, while in all experiments with the same tube the current was always kept at the same three values. So on the short line indicated by each set of three experimental points the points, corresponding to the exact heat flow rates of 0 and 20,000 B.Th.U. per square foot per hour, were marked.

Smooth curves were then drawn among the points corresponding to the same rate of heat flow. In order to get uniformity between the curves for the different velocities, the values of K for the zero heat flow rate—which will be denoted by K_o—taken from these curves for the same water temperature, were plotted against the velocity and slightly eased so as to make these curves also smooth curves. Curves were also drawn giving log K_o for several definite temperatures against log V, which were found to be approximately straight lines with a slope of about 0·8; this is in accordance with the generally accepted relation between these quantities. Above 70 deg. Fah. the curvature of these lines was very slight except at the lowest velocities of 1ft. and 2ft. per second. These curves enabled both the slight irregularities between the curves for different velocities to be smoothed out and the values of K for intermediate velocities to be interpolated with considerable accuracy.

Similar tests were carried out with tubes of ¼in., 1in., and 1½in. nominal outside diameters; in each case the same procedure was followed, so that charts were constructed for tubes of four different diameters, giving the values of K for water temperatures from about 40 deg. Fah. to 150 deg. Fah. for all multiples of velocities of 1ft. per second up to 10ft. or 11ft. per second, and for heat flow rates up to 20,000 B.Th.U. per square foot per hour.

Too much stress must not be laid on the discrepancy seen in Fig. 2 between the spacing of the points at high water temperatures and velocities and the spacing indicated between the zero and 20,000 B.Th.U. per square foot per hour curves. With the hot water points shown at 11ft. per second the three temperature differences from tube to water for the three heat flows were 1·36 deg., 3·97 deg., and 6·50 deg. Fah. These were the results of smoothing the three experimental values graphically against the heat flow rate. Had the points been smoothed to a curve of slightly less curvature so that they became 1·33 deg., 3·95 deg., and 6·50 deg. Fah., the spacing of the points would have been reduced to half that given here. Thus 50 per cent. of the spacing depends on a temperature difference of only 0·03 deg. Fah. As the inlet water was steam heated to about 125 deg. Fah. it was difficult to keep its temperature constant to this degree of accuracy.

The Loss of Hydrostatic Head Along the Tube.—The loss of hydrostatic head over a portion of the heated length was measured in each experiment during the three different rates of heat transfer, and was also measured beforehand in the absence of heat transfer. The latter results agreed very closely, on reduction, with the standard curves given by Stanton and Pannell.

It is not usual to apply Stanton and Pannell's results to

a case when heat transfer occurs, since one does not know what temperature to adopt in finding the viscosity which is required for evaluating $\varrho\, v\, d/\mu$. For instance, if the tube temperature is 80 deg. Fah. and the water temperature is only 60 deg. Fah., the viscosity at the tube wall is 23 per cent. less than its value at the water temperature, and consequently the value of $\varrho\, v\, d/\mu$ is 30 per cent. greater by using the tube temperature instead of the water temperature.

One may expect the loss of head to depend much more on the tube wall temperature than upon the water temperature, since the wall friction must be equal to the water viscosity at the wall multiplied by the radial velocity gradient at the wall. When heat flow is present there is necessarily an axial temperature gradient, so in comparing the experimental results with Stanton and Pannell's curves the tube temperature midway between the manometer connections was taken.

On examining the loss of head during heat transfer it was quickly recognised that the loss was, within the margin of experimental error, sensibly the same as if there had been no heat transfer present and the water had been throughout at the actual temperature of the tube wall. Thus one can say that the loss of head depends upon the tube wall temperature and is independent of any heat transfer taking place. When very cold water, at temperatures down to 40 deg. Fah., could be obtained, this law was seen to be slightly departed from, the loss of head being the same as if no heat transfer were present and the

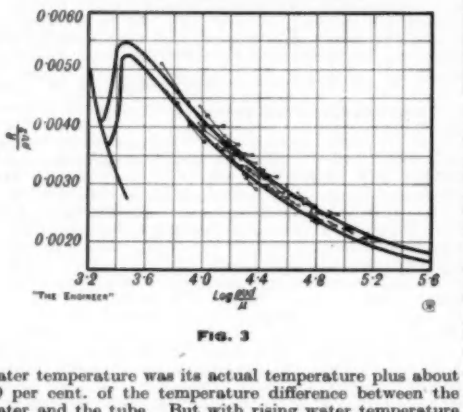


FIG. 3

water temperature was its actual temperature plus about 90 per cent. of the temperature difference between the water and the tube. But with rising water temperature this fraction was soon sensibly 100 per cent. Lack of steadiness of the manometers precluded any very great accuracy being attained in these results. A sample of the results obtained is shown in Fig. 3, in which the results are all plotted against the value of $\log \frac{\varrho\, v\, d}{\mu}$.

[The remainder of the paper included a discussion of the theory of heat transfer, in the course of which Osborne Reynolds's theory on the subject propounded in 1874 was subjected to criticism. The authors advanced a modified theory which led to the formula

$$10{,}000\ V_n/K_o = A + B\,(\sigma - 1) - C\,(\sigma - 1)^2,$$

where K_o is the coefficient of heat transfer at zero rate of heat flow, V_n is the nominal velocity and σ is $\mu\, s/c$, where μ is the viscosity of the fluid, s is its specific heat, and c is its thermal conductivity. In a table values of the "constants" A, B, and C were given, and in another table the value of the quantity σ was shown for water at temperatures from 32 deg. Fah. ($\sigma = 12{\cdot}45$) to 320 deg. Fah. ($\sigma = 1{\cdot}02$). The paper concluded with the discussion of an approximate formula whereby the value of the coefficient of heat transfer K_H, when the rate of heat flow has any finite value can be determined from the corresponding value K_o, given by the above formula for the condition of zero heat flow.—ED. THE E.]

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Coal Problems.

IN the Cannock Chase coalfield and in the South Staffordshire coalfield, the mine owners and the miners have been unable to come to terms despite protracted and friendly negotiations and wage reduction notices, according to statute, are now expected. Though the parties have failed to agree the situation here is not considered to be one of definite deadlock. Leicester district owners and miners have arrived at an agreement for a spread-over of hours, and formal application has been made to the Mining Association and the Miners' Federation for approval. Although the parties at Cannock Chase and South Staffordshire have so far failed to agree, it is understood that upon any alteration in the circumstances, or any new factor arising, the colliery proprietors and the men's representatives would immediately get together again.

Steel Prices.

Though firmness characterises finished steel prices, which are controlled by the Steelmasters' Association, in the semi-finished branch, where there is no control, a decided weakness in selling values is noticeable. Some stringency has developed of late in regard to continental half-products, and prices have stiffened by several shillings. German quotations for billets, indeed, have been withdrawn, a fact attributed to Germany having sold most of her output intended for the export market. Whether these conditions affecting their competitors have had any influence in helping to bring about lower prices for British material by giving local producers encouragement to fight for the trade, is difficult to determine. It would appear this week, however, that sales of native semi-finished steel have constituted a larger proportion than latterly of the business done in this class of material. Re-rollers of continental billets are reputed to have sold small bars at £7 7s. 6d. per ton, a figure 5s. lower than was quoted on the Birmingham market about a week ago. Sales of English billets have been made at £5 12s. 6d., or half-a-crown below the recent minimum. In other directions, also, price weakness is evident. In the tin-plate trade control has broken down, while tin-plate bars have been reduced 15s. to £5 a ton. This figure is still much above the price at which imported bars are to be obtained. Steel works in this district continue to work short time, and orders, particularly for finishd material, are of small content. Conditions in the structural engineering and heavy engineering industries in this area, I regret to say, show no definite signs of improvement.

Raw Iron.

Demand for Midland pig irons has advanced somewhat since the reduction in prices, but it is attributed chiefly to the release of business which had been held up in the hope of some such movement or business which users were considering placing with foreign producers. Consumptive demand at the foundries and forges hereabouts remains small and insufficient to absorb the output of Northamptonshire and Derbyshire furnaces. Consumers do not appear to have increased their specifications since prices were lowered. It was stated on 'Change in Birmingham to-day that there is a certain amount of Luxembourg pig still to come into this district, and that this material is still on offer at £3 6s. 6d. per ton delivered, or 1s. per ton below the present selling figure of Northamptonshire No. 3 foundry iron. It is thought that the move recently made by blast-furnacemen will ensure practically all the available business going to Midland furnaces. It is improbable that continental furnacemen will be able to lower their prices to a point which will give them continued access to the Midlands. Foundrymen will, doubtless, prefer to pay 1s. more for the iron to which they are accustomed and which, undoubtedly, has superior advantages. Purchases of pig iron at date are for small lots, forward contracting continuing to be avoided. It is stated that a portion of the output of local furnaces is going into stock.

Finished Iron.

Makers of wrought iron in the Staffordshire area report no alleviation of the trying conditions under which the industry has for some time now been carrying on. Except in the best bar branch, works continue to operate on a small scale, orders being insufficient to permit of more than a few days' activity each week. There is a fairly regular call for marked iron, but even here production is not maintained at full strength. The recent advance in demand for Crown quality iron has not been sustained, and the makers are again eagerly searching for business. Trade in wrought iron tube strip is moderately good, and here and there makers, well placed for business, are able to command slightly more than the recognised market level of £10 17s. 6d. per ton. Demand for nut and bolt and fencing bars of Staffordshire make is stagnant. What orders there are about, and they are few, find their way to the Continent. The selling price acceptable to Belgian ironmasters cannot possibly be approached by local producers. Marked bar prices are maintained at £12 10s., Crown bars are quoted from £10 to £10 7s. 6d., and nut and bolt quality bars £9 upwards.

Galvanised Sheets.

Millowners' efforts to encourage buying of galvanised sheets by reducing prices of 24-gauge corrugated by 7s. 6d. per ton, have met with some little reward. Inquiries this week have been decidedly more numerous, and some moderate orders on overseas account have also been received. Local millowners' commitments, however, are not large, and greatly increased business will be necessary if work is to continue uninterrupted at the mills. Makers consider that on the basis of £11 5s. per ton for 24-gauge prices are favourable to the buyer and should justify the purchase of forward supplies. The Indian and Scandinavian markets continue to be exempted from price control, owing to the exigencies of international competition. Demand from home sources is on recent levels, and is considered fairly satisfactory.

Railway Contracts for Midlands.

The Great Western Railway has placed contracts with Lotz and Kier, Stoke-on-Trent, for reinforced concrete work to carry a new coal hoist track and traverser track at North Dock, Alexandra Docks, Newport; with Hollings and Guest, Ltd., Birmingham, for the supply and erection of one 6-ton hydraulic jib crane for Smithfield market; and for a new invoice office at Paddington Goods Yard, with William T. Nicholls, Ltd., Gloucester.

Coventry Chain Company.

At the recent annual general meeting of the Coventry Chain Company, Mr. Charles W. Goff, who presided, said that because of the fusion of the interests of that company with those of Hans Renold, Ltd., it had been considered advisable to form a holding company called the Renold and Coventry Chain Company, into which shareholders were invited to exchange their holdings.

Midland Men on Coal Board.

Three Midland men have been appointed by the Secretary of Mines on the National Industrial Board under Part 4 of the Coal Mines Act, 1930. Mr. James Cadman is a J.P. for Newcastle-under-Lyme. He is chairman and managing director of Brereton Collieries, Ltd., and of Norton and Biddulph Collieries, Ltd., and a director of Madeley Wood Collieries. Alderman Fred Hayward has taken a leading part in the Co-operative movement. He was Mayor of Stoke-on-Trent in 1926. Mr. B. Madew is managing director of the West Cannock Colliery Company, Ltd.

Coal Seam at Wednesfield.

What is believed to be a fine seam of household coal, over 3ft. thick, has been found in the sinking of a new shaft at Castle Bridge Colliery, Wednesfield, Staffordshire. The mineral was found at a depth of 50ft.

The Late Mr. W. H. Hawthorne.

Midland industrialists learned with regret this week of the death at Coseley, of Mr. William Henry Hawthorne, senior director and chairman of the board of directors of the Canon Iron Foundries, Ltd., Deepfields. Mr. Hawthorne, who was 69 years of age, had been associated all his life with this well-known Black Country firm, and had many friends amongst iron and steel masters and manufacturers generally throughout the Midlands.

Unemployment.

The increase of 3581 in the number of unemployed in the Midlands area shown in the latest returns, practically wipes out the decline reported a week ago, and leaves the district with 195,261 wholly unemployed, 101,039 temporarily stopped and 396 normally in casual employment, a total of 296,696. In most districts the number of idle hands continues to increase slowly, fluctuations to the one side being followed by changes to the other. In the Birmingham area the total has mounted to 51,740, at Stoke-on-Trent unemployed number 26,712, at Nottingham 12,716, at Leicester 12,106, and at Wolverhampton 11,813. Of the grand total 204,452 are men, 80,847 women, 5881 boys and 5516 girls.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Fleetwood Port Developments.

WITH the programme of development work at Fleetwood docks already undertaken approaching the stage of completion, the London, Midland and Scottish Railway Company is preparing the way for embarking upon a more important scheme at the same port—a reply, so it is assumed, to the development work now in progress at Grimsby by the London and North-Eastern Railway Company. A parliamentary bill is being promoted by the L.M.S. Company to secure powers to proceed with the construction of a new dock at Fleetwood at an estimated cost of £750,000, the principal object being to accommodate a bigger type of trawler by the removal of the existing dock sill and the provision of almost double the present water space available for docking fishing and other vessels. Nearly £250,000 has already been spent by the company on the improvement of marketing and slipway facilities at the port.

£100,000 for Electric Lighting.

An electric lighting scheme for Irlam and Cadishead, near Manchester, has been sanctioned by the Electricity Commissioners, and the work is to be started by the end of the year. Transmission lines will be laid from Flixton to Irlam by the Stretford and District Electricity Board, which has agreed to be responsible for the repayment of principal and interest during a period of twenty-five years. The cost of the scheme will be in the neighbourhood of £100,000, and the Irlam and Cadishead Urban District Council has applied for the necessary loan.

Textile Engineering Merger Again in the Air.

It is believed, although no official confirmation is forthcoming as yet, that another attempt is being made to effect a co-ordination of interest among Lancashire manufacturers of textile machinery. It may be recalled that a little more than twelve months ago an attempt was made to bring about some measure of rationalisation in the industry through the proposed formation of a Textile Machinery Union, the aim of which was to secure sufficient voting control of seven of the principal Lancashire firms in this branch of engineering to be able to requisition shareholders' meetings whenever it was considered necessary. A leading part in this movement was taken by Mr. W. C. Harman, then chairman of directors of John Hetherington and Sons, Ltd., Manchester, but for various reasons the scheme failed to mature.

A Trial Run.

A short trial run on the electrified line between Manchester and Altrincham, work on which is nearing completion, was carried out on Tuesday of this week by the London, Midland and Scottish Railway Company, a train of three third-class coaches being used.

Work: Actual and Prospective.

In connection with the Wanganui power scheme, New Zealand, a contract for about 400 miles of copper transmission cable, representing 500 tons in weight, has been placed with the Salford firm of Frederick Smith and Co. Crossley Motors, Ltd., Manchester, has secured a repeat order from the Crown Agents for the Colonies for sixteen six-wheeled "go anywhere" motor vehicles for the King's African Rifles, stationed in East Africa. Plans have been approved by the Manchester Transport Committee for an extension to its Parr's Wood garage at a cost of £50,000, and the Committee proposes to invite tenders for the supply of fifty additional motor omnibuses at an estimated cost of £82,000.

Engineering Dividends.

An interim dividend of 5 per cent. actual, free of tax, has been declared by the directors of Chloride Electrical Storage, Ltd., Clifton Junction, near Manchester. The board of the recently formed Renold and Coventry Chain Company, the constituents of which are

Hans Renold, Ltd., Manchester, and the Coventry Chain Company, Coventry, has just declared a first interim dividend of 5 per cent. actual.

Non-ferrous Metals.

Apart from lead, which has continued the upward tendency of the two previous weeks, all sections of the non-ferrous metals markets have lost ground since my last report, although the only serious decline has been in the case of spelter. Buying in the copper section has been less active, apart from occasional spurts, and prices have fluctuated somewhat in consequence, though the loss on balance for the week is no more than about 5s. a ton for standard brands. Tin has met with a moderate trade demand, but it is obvious that the offtake of the metal is far from sufficient to maintain values on an upward course, and in spite of a further slight improvement in the statistical position in this section of the market, quotations have given way to the extent of between 10s. and 15s. a ton, according to position. Spelter during the period under review has touched higher levels than since late September but, as with the other metals, the demand is too restricted to make for steadiness, and the net result has been that the week's loss of nearly 10s. a ton has brought prices within measurable distance of their record "low." An advance of 5s. in lead has raised current levels to where they were early last month, and a moderate amount of buying interest has been shown.

Iron and Steel.

The feature of the iron and steel markets in this area during the past week has been a welcome spurt in the demand for pig iron, although up to the present it has not been extensive. Buyers, however, appear to have discarded a good deal of the excessive caution which characterised their operations before this month's reduction, and although there has been only a moderate increase in forward contracts, business in the aggregate has been better than before. Prices are at 69s. 6d. per ton for Staffordshire and Derbyshire pig iron, 68s. for Northamptonshire, 64s. 6d. for forge quality, about 91s. for Scottish pig iron, and 84s. 6d. for West Coast hematite, all delivered equal to Manchester. There has been no corresponding improvement in the case of steel, however, and with few contracts still to run users are holding off the market as much as possible in the hope of securing more favourable rates later on. Unfortunately, there is little in the position of the majority of Lancashire engineering concerns to justify extensive commitments. Sales of continental products are quiet, and at the moment values are largely nominal, with, however, a decidedly firmer undertone in evidence than for many months.

BARROW-IN-FURNESS.

Hematite.

The slight improvement which was noticeable in the hematite pig iron market has not developed; in fact, it is doubtful if the demand has been maintained. There does not seem to be any definite sign of betterment, and low as the present output is compared with normal, a considerable amount of iron is going into stock. The quietness in the pig iron market is not altogether accountable for this increase of stocks; the stagnation in the steel trade being an important factor. Orders continue to be small and are placed simply to meet immediate requirements. Foreign business is quiet. The iron ore trade, both native and foreign, is naturally dull in sympathy with the iron trade. There is still practically nothing being done in the steel trade, and the rail departments are not working. The Barrow mills have been idle for a considerable period and only the hoop mills have had orders to handle. At Workington things are almost as bad. It may be that, in the future, Workington may have orders for sleepers, but that largely depends upon tests which are being made. The great fear about steel sleepers is corrosion, but it is thought that that will be overcome.

SHEFFIELD.

(From our own Correspondent.)

Dull Trade Conditions.

In Sheffield the steel industry continues in a state of depression. The open-hearth basic steel departments are very short of work, but, although plants producing crude steels are receiving no substantial orders, there has been no further curtailment of orders. One difficulty is that whilst certain firms are receiving orders fairly frequently, they are for small quantities, and large orders in any department are very rare. In the finished and lighter sections there is a fairly regular flow of very small orders. At the same time, there is no feeling of pessimism; on the contrary, there is a certain amount of optimism, which is based on the fact that more inquiries are being received by some sections of the industry. Improvement is hoped for in the near future, but it will have to be considerable before local works become at all busy.

Steel Works Close Down.

It has been decided to close the Redbourne Hill Works at Scunthorpe, which are owned by Richard Thomas and Co., the South Wales tin-plate firm. These works have been producing about 1200 tons of basic steel ingots per week and employing some 2000 persons, practically the whole of whom have now lost their employment. It is not known when the works will be reopened. They were closed 4½ years back, and then a little more than a year ago the plant was brought up to date and partially restarted. Since then the works have been producing sheet and tin-plate bars for the Welsh firm's works. The decision to close down is not unexpected, and it reflects the stagnant condition of the basic steel industry in Lincolnshire, where practically all works are poorly employed.

Government Orders.

Several firms in the Sheffield district have recently secured orders from Government Departments. Thos. Firth and Sons, Ltd., Sheffield, are to supply cast steel doors and condensers to the contract and purchase department of the Admiralty, which has also placed orders with Gladwin, Ltd., of Sheffield, for electro-plate, and the Chesterfield Tube Company, Ltd., of Chesterfield. For the War Office, John Brown and Co., Ltd., of Sheffield, are to supply gun billets; the English Steel Corporation, Ltd., of Sheffield, round steel; and the United Strip and Bar Mills, Ltd., of Sheffield, medium tensile steel. The Post Office is obtaining ducts from the Hepworth Iron Company, Ltd., of Sheffield, and telephone exchange equipment from the D.P. Battery Company, Ltd., of Bakewell.

Engineering Works Acquired.

Sanction of the court has been obtained for the proposal of the Sheffield firm of Thos. W. Ward, Ltd., to acquire the undertaking of the Laycock Engineering Company, Ltd., Millhouses, Sheffield, and it is expected that they will take over the concern at an early date. Nothing definite has yet been decided by Wards, but it is believed that a scheme is being considered for the continuance of the business. This will be welcomed by the employees of the Laycock Company, who are displaying interest in a rumour which credits the new owners with developing a new line of business that should provide a promising field of development. The works are by no means obsolete, being well equipped with modern machinery for the manufacture of all kinds of railway, steamship, motor car, omnibus and tramway appliances, as well as for general engineering work. Mr. W. S. Laycock founded the business in the early 'eighties, and it was incorporated as a limited company in 1900. At various times the works have supplied appliances to all the leading railway and steamship companies in the world. During the war it made 100 H.P. aeroplane engines, and later the 12–25 H.P. Charron-Laycock motor car. The production of the motor car had to be abandoned, however, and in 1925 the Laycock Engineering Company, Ltd., was formed. Since then the plant has been principally occupied in the production of railway appliances and the component parts for motor cars—axle-boxes, front and rear axles, gear-boxes, engines, steering and braking gear—high-pressure washing plant for garages, &c.

American Monopoly Challenged.

Adjustable iron planes of the American pattern are now being produced by the Sheffield firm of C. and J. Hampton, Ltd. This is an important development of local industry, inasmuch as large quantities of this type of plane are imported every year from the United States, which have had a monopoly in the trade. The Sheffield-made tool is stated to be equal to the American product in all respects, and, in addition, to have an advantage through being fitted with a cutting iron made of tungsten steel, which cuts faster and lasts longer than the steel which has always been used for the purpose. The new tool also has non-rusting nickel-plated small screws, and is said to have been well received, both by distributors and users.

South African Orders Missed.

Considerable disappointment is felt in Sheffield trade circles that, although the greater part of the work in connection with the erection and equipment of the steel works which are to be established near Pretoria, South Africa, has been given to British firms, none will come to Sheffield. Steel is required for the erection of shops, blast-furnaces, steel furnaces, rolling mills and coke ovens, and Sheffield firms were hopeful of securing orders for the internal manufacturing plant, but that part of the order has been placed in Germany, although Sheffield has at least two firms admirably equipped for all sorts of heavy iron and steel works plant.

Railway Work Shortage.

Manufacturers of railway materials in Sheffield have been short of work for a long time past, and there are no indications of any improvement in the position. Home companies are following a strictly economical policy, and the number of orders from foreign countries and the Dominions has fallen away considerably in recent years. In no case has there been a greater shrinkage of this class of work than in connection with the Indian railways. At one time Sheffield firms relied upon orders from India to keep their plants employed for a substantial part of the year, and orders for axles, tyres, wheels, buffers and springs were numerous. But since the adoption by the Government of India of the definite policy of buying in the lowest satisfactory market without any regard for preferential treatment of British manufacturers, orders from India have shrunk in volume. That is clearly shown by a report of the India Store Department in London for the year 1929–30, during which nearly half the orders were placed in countries other than Great Britain. A further important factor is that important works have been equipped in India for the production of materials which used to be bought in Sheffield. Germany and the United States have received considerably more Indian orders.

Sheffield Trade Mission.

It is stated that the Sheffield Trade Mission, headed by Mr. A. K. Wilson, ex-Master Cutler, has met with considerable success during its tour of South America, and the Overseas Trade Development Council has been so encouraged by the success that it is hoped that other industrial centres will co-operate with the Government in the same way as Sheffield has done. In his last message, Mr. Wilson stated: "We have found people not only ready, but anxious to give us every possible assistance to enable us to place before the manufacturers of Sheffield a clear and concise report of what the market wants to buy, and there is no doubt that should our manufacturers be able to give them the type of articles which they want at equal and in some cases slightly higher prices, importers will be only too glad to place their business with us." The Mission is expected to arrive back in this country on December 19th.

Australian Premier's Visit.

When Mr. J. H. Scullin, Prime Minister of Australia, visited Sheffield for the purpose of receiving the honorary freedom of the city, several firms took advantage of the opportunity to invite him to see for himself some of the local industrial activities. He visited the works of the English Steel Corporation, Ltd., Hadfields, Ltd., Mappin and Webb, and Walker and Hall. At Hadfields he saw one of the largest steel foundries in the world, and was specially interested in steel rails similar to those just supplied in large quantities to the New South Wales Railways. It is hoped that Mr. Scullin's visit will exercise some good influence on trade with the Commonwealth.

The Lighter Trades.

There has been a decrease in the number of seasonal orders for cutlery and plate, and the suggestion is made that to some extent this is due to a tendency for other articles to be chosen for gift purposes. Export trade generally is quiet. Despite keen competition at home and abroad, considerable quantities of safety razor blades are being produced locally. Electro and silver plate manufacturers are not busy, but there is a fairly good demand for spoons and forks, particularly for cheaper qualities. Exception has been taken to a statement by Mr. Philip Snowden that the Scandinavian markets are being neglected, and his suggestion that it is difficult to obtain a British saw in Norway. Sheffield firms actually do a good business in Norway, particularly in circular saws, and they have regular travellers in that country.

NORTH OF ENGLAND.

(From our own Correspondent.)

Iron and Steel Trade Prospects.

While the general trend of business in the iron and steel industry of the North of England shows little actual change so far as turnover is concerned, the outlook is certainly improving, and in some quarters there is a feeling that the long depression is coming to an end. This is always a very quiet period of the year, and it may be said that on the whole there is a fair measure of optimism that the early months of next year will witness a gradual expansion of trade. An encouraging feature is the placing of many large contracts involving the use of considerable quantities of constructional steel. When this work is put in hand, the activity of the steel-producing plants and rolling mills should be increased. Dorman, Long and Co., Ltd., Middlesbrough, have recently secured several important contracts. The latest is for a new bridge and approaches at Rhyll, the inclusive price being £66,000. This contract includes the supply of two 150ft. bridge spans, carrying a 20ft. road and two footpaths; the sinking of two caissons by the pneumatic process 89ft. into the bed of the river, the construction of two concrete abutments 35ft. high, a concrete sea wall 300ft. long, and approach roads. Work will begin immediately, and the contract time is fifteen months. All the steel, approximately 600 tons, will be manufactured at the firm's Middlesbrough works, and all materials and plant will be of British manufacture. Orders to the value of £146,500 have been given out this week by the Newcastle-on-Tyne Electric Supply Company in connection with the giant power station to be built at Dunston for the change-over of electric supply frequency under the grid scheme for the North-East Coast. Of this amount £129,000 is included in a contract for the steel-frame buildings of the boiler-house and engine-room to be supplied by Dorman, Long and Co., Ltd.

Cleveland Iron Trade.

Business in the Cleveland pig iron trade is still checked by the low terms on which foreign products can be purchased. Values of some imported materials tend to harden, but substantial advances in prices from abroad are needed to enable producers here to compete successfully in certain markets. Of the 93 blast-furnaces on the North-East Coast no fewer than 68 are idle, and there seems little likelihood of much inoperative plant being re-kindled until the spring of next year, though the limited output of pig iron does not quite satisfy current requirements. Cleveland pig iron producers adhere to their fixed minimum prices, though it is understood that concessions have been granted to customers in Scotland. Belgian iron is reported to have been bought for consumption on Tees-side at 48s. f.o.b. Antwerp, which is equal to delivery at North-East Coast ports at about 9s. below the quoted price of Cleveland iron. Midland iron is also being a little more extensively used in this area. No. 1 Cleveland foundry iron is 66s.; No. 3 G.M.B., 63s. 6d.; No. 4 foundry, 62s. 6d., and No. 4 forge, 62s.

Hematite Pig Iron.

The gradual strengthening of the statistical position of the East Coast hematite pig iron trade encourages sellers to take a firmer stand. Merchants have reduced their holdings considerably and are not now inclined to accept lower prices than are named by makers. Overseas customers are placing occasional small orders. Prices are steadily maintained at the equivalent of ordinary qualities at 71s., with No. 1 quality at a premium of 6d. per ton.

Ironmaking Materials.

Foreign ore business is almost at a standstill. Prices are based on best Rubio at 16s. per ton for prompt cargoes, but that figure would not be accepted for forward contracts. Sellers of blast-furnace coke experience much difficulty in inducing consumers to negotiate for supplies. For good average qualities 17s. is asked, but users will not pay that price.

Manufactured Iron and Steel.

Improved conditions are reported in the manufactured iron and steel trade, but a greater accession of orders would be welcomed. Tonnage output in two or three sections keeps fairly heavy. Producers of constructional

steel and railway requisites are better employed than are manufacturers of several other commodities, and sheet makers have fairly good order books. No price changes are reported.

The Coal Trade.

In all sections of the coal trade there is considerable anxiety in reference to the outcome of the various negotiations taking place concerning the working of the new Mines Act. A few inquiries are coming forward from abroad for coal deliveries during the first quarter of next year, but there is no definite pressure, and with stocks of all grades of coal apparently abundant at all continental centres, the consumers regard the position as being very favourable and show no anxiety as to the future outlook. German competition is stated to be further developing, and with the labour wages being reduced the prospects point to still further price competition. For the next four or five weeks there is no special business in circulation, but the owners in all classes of coal anticipate that the present output will be fully taken up, although they do not expect any increased demand. Hence, production will be maintained at the recent level and prices will be unchanged. Speculators, of course, fear stoppages at home centres, and, therefore, are not inclined to commit themselves to definite forward sales. Best Northumberland steams are nominally steady at 13s. 6d. for large and 10s. for small, but through contract holders who are keen to get rid of their commitments 3d. and 6d. price concessions are available. There is a good general demand for all best class Durham coal, and tonnage is well stemmed. Stocks are limited and prices are firmly held at 14s. 9d., and for special classes 15s. 9d. is the minimum. Secondary qualities, however, are offered freely at an unchanged price of 12s. 6d. Coking unscreened are moving off steadily at 12s. 6d. to 13s. Bunkers are plentiful and easy in tone at 12s. 6d. The demand for gas coke is well maintained, and the daily output is fully taken up. Stocks remain low, and for any small parcels available 21s. 6d. is firmly maintained. Patent oven coke is plentiful and is offered freely at 17s. Beehive and other special grades are at 24s. to 28s.

SCOTLAND.

(From our own Correspondent.)

No Change in Markets.

THE past week has brought no appreciable change in the steel, iron, and coal markets. So far as the first two are concerned, interest is centred on the firming tendency on the Continent, where in some cases prices have been withdrawn and manufacturers generally are not so ready to accept the keen rates formerly ruling. This change of front may be temporary, but any movement of this nature holds a certain amount of encouragement for local producers, who continually look for a lessening of foreign competition at home and abroad. In the coal market the possibility of a stoppage of work pending a settlement of the question of hours and wages engages chief attention at present.

Steel and Iron.

Reports generally show that business holds no sign of improvement. Orders from all sources are extremely scarce, and the plants in operation are not kept in regular employment. The requirements of steel plates and sections are far below expectations, owing to the lack of shipbuilding orders, and a very poor export demand. Steel sheets are quiet, especially in the galvanised descriptions, which suffer from the unrest in India and continental competition. Steel tubes are slack in all departments. The depression in the bar iron and steel re-rolling industry continues unabated. Prices are nominally unchanged, with re-rolled steel bars at £7 7s. 6d. home and £7 5s. per ton export, but somewhat easier terms could be arranged for a good prompt order. The output from the ten pig iron furnaces in blast in Scotland is ample to meet all present demands, owing to keep competition in the shape of continued imports from India and the Continent. Though steel and iron makers generally are not disposed to look for any improvement in the meantime, they realise that any slight expansion in business would result in heavy buying, as prices are very depressed and stocks throughout the world are light.

Scrap.

The market for scrap is easier, business being quiet and transactions limited in quantity. Heavy steel is quoted about 50s. and cast iron machinery 60s. per ton.

Coal.

The export coal market continues quiet, as importers abroad are not disposed to consider the prices quoted from here and are not influenced by the talk of a strike. Business is still of a day-to-day character, and a strike would simply mean that importers abroad would draw all supplies from Poland and Germany. Meanwhile, the tendency in the shipping market is firmer, especially in the case of washed nuts, the smaller sizes of which have been in better demand for local consumption and for shipment to the Thames. Round coals are plentiful in all districts, but there is a tendency to hold up supplies in view of the possibility of a stoppage of work, and prices may take an upward turn at any moment. Aggregate shipments amounted to 239,576 tons, against 220,444 tons in the preceding week, and 267,197 tons in the same week of last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Prospects.

THERE has been only one subject of discussion in this area during the past week, namely, the coal industry, which is the staple industry of South Wales. The question on every one's lips has been what is going to happen at the end of the week? Up to the time of writing, there was practically nothing to give a definite indication as to whether there would be a stoppage of work on Monday, or whether operations would continue. All that can be said is that the majority of opinion prevailing is that there will be no stoppage. An emergency meeting of the executive council of the South Wales Miners' Federation decided on Saturday last to submit matters affecting a new wages agreement to the National Board, seeing that no agreement had been come to with the South Wales coalowners. It was also decided to call a South Wales Miners' conference at Cardiff on Saturday next to receive a report of the progress made in London. Lodges have also been asked to arrange for meetings so that the men can receive reports from the delegates to the conference. The National Industrial Board in London was due to consider the case for South Wales on Thursday, and, in view of the conferences later, it looks as if it will not be until the eleventh hour that the workmen and all who are interested in the export trade will know where they are. This uncertainty is very harmful. It is difficult to see how any agreement between the parties can be come to in the short time existing before the seven and a-half-hour day operates on December 1st. North Wales coalowners and miners have agreed to a spread-over scheme, but those in South Wales have not done so, and, in fact, there are rumours that the coalowners themselves are not unanimous on this question. However that may be, the course that the coalowners are expected to adopt is to make known to the miners what their terms of work will be at the pits as from Monday next, and there can be little doubt that they will involve reductions in pay and the modification of existing working conditions as a set-off to the reduction in working hours.

Coalowners' Terms of Work.

South Wales coalowners have now issued their terms and conditions of employment at collieries as from December 1st under the 7½ hours' day. They entail a reduction in the percentage payable on the 1915 standard rates from 28 to 10 per cent. The subsistence wage, now standing at 7s. 10½d., is altered to a scale varying according to standard rates and actual earnings, but ranging from a minimum of about 6s. 3d. to a maximum of 7s. The owners also stipulate for the abolition of the bonus turn to workmen on the afternoon and night shifts. This is to be replaced by the men receiving payment at existing standard rates, plus percentage according to the actual number of shifts worked. Present rates of overtime will be continued, but will not be paid to a workman for any shifts or parts of shifts which constitute his regular working week. Double shift shall be worked when required and workmen will be entitled to house coal for domestic purposes in accordance with previous practice. In forwarding the terms and conditions to the secretary of the South Wales Miners' Federation, Mr. Finlay A. Gibson states that the owners have no alternative but to propose terms and conditions and to post them at the collieries, as the South Wales Miners' Federation has declined to discuss with the owners' representatives the question of a reduction in wages necessitated by the reduced amount of work which workmen can perform in the shorter hours of working and by the serious financial plight of the industry.

Export Business.

In the meantime, there has been extremely little fresh business transacted in coals for export. The fear of a stoppge has not meant to any appreciable extent the buying of additional prompt cargoes. Foreign consumers are not perturbed by the prospect. They know that stocks of continental coals are extremely heavy, and in the case of Germany amount to between 9 and 10 million tons. Already exporters and importers have received intimation that continental producers are prepared to meet all their requirements. A suspension of work in this country would exactly suit their book. All that has happened during the past week or so is that foreign undertakings have asked that the delivery of cargoes previously sold should be expedited in a number of cases, and, of course, exporting firms on this side have endeavoured to meet their clients' wishes; but so far as fresh business operations are concerned, they have been more or less in a state of suspense. In order to effect the quick shipment of cargoes by the end of this week, there was a demand at the end of last week and at the beginning of this week for steamers that could be immediately ready, and, of course, outward rates of freight showed an improvement. That was especially so in the case of tonnage required for West Italy, and rates of 7s. and 7s. 3d. were conceded; but since then tonnage with readiness next week has been fixed at 6s. 3d., so that it will be seen that the improved freight market did not last long. Steamers are laying up in increased numbers in consequence of the unremunerative state of trading generally.

Import Trade.

The development of the import trade is one of the directions in which efforts are being concentrated in this district. The Great Western Railway Company has made and maintained provision for it, and it is interesting to note that last week the first consignment of Canadian cattle for some years past was landed at Cardiff. The s.s. "Salacia" brought from Calgary, Canada, 150 head of cattle, which were discharged at the Roath Dock, Cardiff, where every facility is available for dealing with this traffic. The cattle were disposed of by private treaty, most of them being dispatched to London immediately. Cardiff is one of the few ports in Great Britain at which like cattle may be imported, being licensed for this purpose by the Minister of Agriculture and Fisheries.

Coal Values.

One feature of the coal trade during the past week or so has been the improvement of the inland demand, and those qualities which are specially adapted for industrial purposes have met with a much better outlet. Dry coals have shown a better tone, and in some cases have been able to command prices slightly above the minima. In other cases there has been no change and, unfortunately, collieries have not benefited much in some cases by the extra shipments called for by some of their clients, for the reason that tonnage which was expected to make early readiness has been considerably delayed by the bad weather prevailing, which has meant that boats have had to shelter, while work on others discharging has been slower. Patent fuel and coke have been in quiet demand, but pitwood has improved to 25s. to 25s. 6d.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

R. A. LISTER AND CO., Ltd., of Dursley, Gloucester, ask us to announce that they have opened new showrooms and offices in Imperial House, Kingsway, London.

FEDERATION OF BRITISH INDUSTRIES asks us to announce that it has moved its offices from 39, St. James's-street, London, S.W. 1, to No. 21, Tothill-street, Westminster, S.W. 1.

THOS. W. WARD, Ltd., asks us to announce that its proposal to acquire the undertaking of the Laycock Engineering Company, Ltd., Millhouses, Sheffield, has been sanctioned by the Court, and that it expects to take over that concern at an early date.

NEWTON, CHAMBERS AND CO., Ltd., of Sheffield, ask us to announce that they have made arrangements with Mr. Arnold Walters, director of Christmas and Walters Ltd., 8, Grosvenor-gardens, Westminster, S.W. 1, to represent them in respect of those products they have acquired from Messrs. Dewhursts, as set out in a note which appeared under this heading in our issue of November 7th last.

ELECTROMERSIBLE MOTORS AND PUMPS, Ltd., of Abbey House, Westminster, S.W. 1, asks us to announce that, having acquired the goodwill, drawings, patterns and data of Submersible Motors, Ltd.—in liquidation—together with the Reed Cooper patents relating to submersible motors and pumps, it has opened new works for the production of its patented submersible pumping equipments at Hammond-road, Southall, Middlesex.

THE DEPARTMENT OF OVERSEAS TRADE asks us to announce that a branch office of His Majesty's Trade Commissioner's Office in the British West Indies will be opened in Jamaica early in the New Year. Mr. Massie-Blomfield has been appointed to take charge of the new office, and will be available at the Department of Overseas Trade from December 8th to 10th to interview British firms interested in trade with Jamaica and British Honduras.

JOHN THOMPSON WATER TUBE BOILERS, Ltd., of Imperial House, Kingsway, London, W.C. 2, asks us to announce that in order to obtain closer co-operation, the associated companies of John Thompson, Ltd., are transferring their drawing-office, estimating office, &c., from London to their works, so that in future all tendering and projects will be dealt with from Wolverhampton and Dudley. All the companies in the John Thompson group, *i.e.*, John Thompson Water Tube Boilers, Ltd., John Thompson (Wolverhampton), Ltd., John Thompson (Motor Pressings), Ltd., John Thompson (Dudley), Ltd., John Thompson Beacon Windows, Ltd., and Kennicott Water Softener Company, Ltd., will continue to have offices in Imperial House, Kingsway, W.C. 2, and a London director or manager and staff will be attached to each company, but at Wolverhampton and Dudley will be the head offices for the whole of the companies in the group.

CONTRACTS.

J. W. JACKMAN AND CO., Ltd., of Manchester, has received from the Austin Motor Company, Ltd., of Birmingham, an order for the full equipment of moulding and core making machines of the Osborn type, in connection with the latter company's new foundry re-organisation scheme.

GLEDHILL-BROOK TIME RECORDERS, Ltd., of Huddersfield, has received a repeat order for 149 G.B. time recorders for use in Admiralty dockyards. The same firm has also received an order from the Overseas Trade Department to supply all the cash registers that will be required—between 50 and 60—at the British Empire Exhibition in Buenos Aires next March.

DORMAN, LONG AND CO., Ltd., of Middlesbrough and London, have received from the Joint Committee of Denbigh and Flint County Councils an order for the construction of the new Voryd Bridge and approaches at Rhyll, the inclusive price being £66,000. The work will include the supply of two 150ft. bridge spans, carrying a 20ft. wide road and two footpaths, sinking two caissons by the pneumatic process 89ft. into the bed of the river, the construction of two concrete abutments 35ft. high, a concrete sea wall 300ft. long and the approach roads.

THE GENERAL ELECTRIC COMPANY, Ltd., of Magnet House, Kingsway, London, W.C. 2, has received from the London Underground Railways Company an order for the supply of some 300 heavy traction motors for the new rolling stock required in connection with the Cockfosters-Hounslow extension of the Piccadilly line. The same company also received, through the Birmingham Railway Carriage and Wagon Company, Ltd., an order for the complete electrical equipment of 61 new compartment-type coaches now being constructed to the order of the Metropolitan Railway Company, London. The material to be supplied will comprise electric traction, lighting and heating equipment for 14 four-motor motor coaches, 14 driving trailer coaches, 14 first-class trailer coaches, and 19 third-class trailer coaches. The motor coaches will each have a power output of 1100 H.P., and will each be equipped with four self-ventilated motors rating at 275 B.H.P. on the one-hour rating. The control gear will be of the electro-pneumatic type.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received an order in connection with the Lanarkshire Hydro-electric Scheme, which covers the conversion, from 25 cycles to 50 cycles, of the four main generating units—two of 7000 H.P. and two of 4000 H.P.—at Bonnington and Stonebyres power stations, which machines were originally supplied by the same firm. The conversion of one 7000 H.P. set at Bonnington has already been carried out. The stators of the alternators are being re-wound at site, while the rotors will be returned to the Stafford Works for conversion from 8 to 16 poles. The same firm has also received an order from the Buenos Aires Great Southern Railway, the new stock for which will include three eight-coach trains, each train having attached to it a self-propelling Diesel-electric power-house. For this stock the English Electric Company is to supply 62 motors, each of 135 H.P., and control equipments. The company is also to supply six motors and control equipments for a 1700 H.P. high-speed Diesel-electric locomotive, which is under construction. The main contractors for the rolling stock are Sir W. G. Armstrong, Whitworth and Co., Ltd., who will also manufacture the Diesel engines.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	17/9 to 20/6
(1) Spanish	20/6 to 21/–
N.E. Coast—	
Native	18/– to 21/–
Foreign (c.i.f.)	16/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	3 17 0	—
No. 1 Foundry	3 19 0	—
No. 3 Foundry	3 16 6	—
N.E. Coast—		
Hematite Mixed Nos.	3 11 0	3 11 0
No. 1	3 11 6	3 11 6
Cleveland—		
No. 1	3 6 0	3 6 0
Siliceous Iron	3 6 0	3 6 0
No. 3 G.M.B.	3 3 6	3 3 6
No. 4 Foundry	3 2 6	3 2 6
No. 4 Forge	3 2 0	3 2 0
Mottled	3 1 6	3 1 6
White	3 1 6	3 1 6
Midlands—		
(c) Staffs.—	(*Delivered to Station.*)	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 6 0	—
„ „ Foundry	3 11 0	—
(c) Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
(3) Lincolnshire—		
No. 3 Foundry	—	—
No. 4 Forge	—	—
Basic	—	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 3 6 (*a*) / 4 5 6 (*b*) / 4 10 6 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	10 5 0	9 15 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 10 0	—
Common Bars	10 15 0	—
Best Bars	11 5 0	—
Double Best Bars	11 15 0	—
Treble Best Bars	12 5 0	—
Lancs.—		
Crown Bars	10 5 0	—
Second Quality Bars	8 15 0	—
Hoops	13 0 0	—
S. Yorks.—		
Crown Bars	10 5 0	—
Best Bars	11 0 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	10 0 0 to 10 7 6	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	9 0 0 to 9 5 0	—
Gas Tube Strip	10 17 6	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates (Marine)	10 10 0	10 10 0
„ „ (Land)	10 0 0	10 0 0
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	8 15 0	8 15 0
Sheets (Gal. Cor. 24 B.G.)	11 15 0	11 12 6

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 10 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	8 2 6	—
Soft Billets	6 17 6	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 10 0	—
Light Rails	8 15 0 to 9 0 0	—
Billets	6 15 0 to 9 10 0	—
Manchester—		
Bars (Round)	9 7 6	—
„ (Small Round)	7 7 6	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	9 7 6	—
Sheffield—		
Siemens Acid Billets	9 10 0 (basis)	—
Hard Basic	9 2 6 and 9 12 6	—
Intermediate Basic	7 12 6 and 8 2 6	—
Soft Basic	6 10 0	—
Hoops	10 5 0	—
Soft Wire Rods	8 0 0	—
Midlands—		
Small Rolled Bars	7 7 6 to 8 5 0	—
Billets and Sheet Bars	5 12 6 to 6 10 0	—
Galv. Sheets, f.o.b. L'pool	11 5 0	—
(2) Staffordshire Hoops	10 0 0	—
Angles	8 7 6	—
Joists	8 10 0	—
Toes	9 7 6	—
Bridge and Tank Plates	8 17 6	—
Boiler Plates	9 10 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14 f.o.b.	16/3 to 16/6
Block Tin (Cash)	113 17 6
„ (three months)	115 5 0
Copper (cash)	47 5 0
„ (three months)	47 7 6
Spanish Lead (cash)	16 1 3
„ „ (three months)	15 18 9
Spelter (cash)	14 7 6
„ (three months)	15 0 0
Manchester—	
Copper, Best Selected Ingots	50 5 0
„ Electrolytic	53 0 0
„ Strong Sheets	84 0 0
„ Tubes (Basis Price), lb.	0 1 0
Brass Tubes (Basis Price), lb.	0 0 10½
„ Condenser, lb.	0 1 0½
Lead English	17 12 6
„ Foreign	16 5 0
Spelter	14 15 9
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/6 per lb.	
Ferro Tungsten	2/3 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 5 6	7/–
„ „ 6 p.c. to 8 p.c.	£22 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£22 0 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£33 0 0	10/–
„ „ „ 1 p.c. carbon	£38 0 0	13/–
„ „ „ 0·70 p.c. carbon	£41 0 0	14/–
„ „ „ carbon free	11d. per lb.	
Metallic Chromium	2/7 per lb.	
Ferro Manganese (per ton)	£11 15 0 for home	
„ „ „	£11 5 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£11 10 0 scale 5/– per unit	
„ „ 75 p.c.	£18 0 0 scale 7/– per unit	
„ Vanadium	12/9 per lb.	
„ Molybdenum	4/2 per lb.	
„ Titanium (carbon free)	11d. per lb.	
Nickel (per ton)	£170 to £175	
Ferro Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	12/6
„ „ Ell	14/6
„ „ Splint	14/6 to 15/6
„ „ Trebles	12/9
„ „ Doubles	12/3
„ „ Singles	11/6
Ayrshire—	
(f.o.b. Ports)—Steam	13/–
„ „ Jewel	16/–
„ „ Trebles	13/–
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	11/6 to 12/6
Screened Navigation	16/6 to 17/6
Trebles	13/6 to 16/–
Doubles	12/6
Singles	11/6
Lothians—	
(f.o.b. Leith)—Best Steam	11/–
Secondary Steam	10/9
Trebles	13/3
Doubles	12/– to 12/3
Singles	11/6

ENGLAND.

(8) N.W. Coast—	
Steams	20/6 to 21/–
Household	32/6 to 53/6
Coke	21/– to 22/–
Northumberland—	
Best Steams	13/6
Second Steams	12/–
Steam Smalls	10/– to 10/6
Unscreened	12/6
Household	25/– to 37/–
Durham—	
Best Gas	14/9 to 15/–
Second	12/9 to 13/–
Household	25/– to 37/–
Foundry Coke	24/– to 26/–
Sheffield—	Inland.
Best Hand-picked Branch	25/6 to 27/– —
Derbyshire Best Bright House	20/– to 22/6 —
Best House Coal	19/6 to 20/6 —
Screened House Coal	17/6 to 19/– —
„ „ Nuts	14/6 to 16/6 —
Yorkshire Hards	14/– to 15/6 —
Derbyshire Hards	14/– to 15/6 —
Rough Slacks	8/6 to 9/– —
Nutty Slacks	6/6 to 7/– —
Smalls	3/– to 5/– —
Blast-furnace Coke (Inland)	11/– on rail at ovens
Furnace and Foundry Coke (Export), f.o.b. 16/6 to 17/–	

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	20/–
Second Smokeless Large	18/9 to 19/9
Best Dry Large	18/6 to 18/9
Ordinary Dry Large	17/6 to 18/–
Best Black Vein Large	18/3 to 18/6
Western Valley Large	18/– to 18/3
Best Eastern Valley Large	17/7½ to 17/9
Ordinary Eastern Valley Large	17/6 to 17/7½
Best Steam Smalls	13/3 to 13/6
Ordinary Smalls	11/6 to 12/9
Washed Nuts	17/6 to 21/6
No. 3 Rhondda Large	20/– to 20/6
„ „ Smalls	15/6 to 16/–
No. 2 „ Large	17/– to 17/3
„ „ Through	16/– to 16/6
„ „ Smalls	14/– to 14/3
Foundry Coke (Export)	27/6 to 35/–
Furnace Coke (Export)	17/6 to 20/–
Patent Fuel	21/6
Pitwood (ex ship)	26/– to 26/6
Swansea—	
Anthracite Coals:	
Best Big Vein Large	35/– to 37/6
Seconds	27/– to 31/6
Red Vein	23/6 to 27/–
Machine-made Cobbles	41/6 to 45/–
Nuts	40/– to 46/–
Beans	24/6 to 28/–
Pens	21/– to 21/6
Breaker Duff	9/9 to 10/3
Rubbly Culm	9/– to 9/6
Steam Coals:	
Large	19/6 to 21/6
Seconds	18/– to 19/6
Smalls	12/– to 13/–
Cargo Through	15/6 to 16/–

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire, and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate: Joists (minimum), 12/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 10/– if home consumers confine purchases from associated British Steel Makers. (*e*) Delivered Black Country Stations.

French Engineering Notes.

(From our Correspondent in Paris.)

Public Works.

THE distribution of large orders for locomotives and wagons has given some appearance of activity to the engineering trades, but that counts for little in the general situation, which is steadily becoming worse. The continual decline in foreign trade, the falling railway receipts, the decrease in State revenues and increasing costs are shaking the optimism concerning the industrial outlook that has long existed. The French have awakened to the necessity of doing something to save a situation which is rendered increasingly difficult by the fact that costs are going up, while in nearly all other producing countries on the Continent they are being brought down by wage reductions and a lowering of prices of commodities. In Italy a bold stroke has been made with a 10 per cent. cut in all prices. The French now see that they must do everything possible for a general reorganisation of industry and commerce on the Continent. That will necessarily take a considerable time, and the problem appears to be elusive, but, until some kind of solution is found, the French are looking for safety to the carrying out of the national programme of public works. Parliament is now sanctioning the expenditure of the Treasury surplus of 5000 million francs which the Government had set aside when it was seen that public works were held up by the considerable reduction in the quantity of material supplied by Germany on account of reparations. The Young Plan limited that supply, which may possibly cease altogether in the near future, in which event it is by no means certain that the programme will be carried out in its entirety. The expenditure will be spread over a period of five years, and much of it will be devoted to the completion of port equipments, road, railway and canal improvements, aviation and the construction of fast transports for the Mediterranean. The Colonies, too, are being authorised to issue loans for public works. Equatorial Africa will raise money for the completion of the railway between the Congo and the Atlantic coast, and for the construction of a new deep-water port at Pointe Noire. All this will help to provide some basis of activity in the engineering trades for some time to come.

Flood Reservoirs.

Early in the year work was started upon one of the numerous reservoirs which it is proposed to create in the upper valley of the Seine for the multiple purpoces of protecting Paris against floods, returning water to the Seine during times of drought, producing electrical energy, and also adding, possibly, to the water supply of the Capital. The first reservoirs are experimental, and upon the practical results obtained from them will depend the construction of others. It cannot be said that there is unlimited confidence in the salutary influence of the reservoirs upon the Seine, for, notwithstanding the large amount of water held up, it will represent only a very small proportion of the quantity that at times flows down the valley of the Seine. It must, nevertheless, have some effect, and it is believed that the advantages to be derived from these artificial lakes in a region where the territory is of little value will justify the cost of their construction. In times of drought, for example, the volume of water passing through Paris may fall to 35 cubic metres a second, and Paris takes normally 21 cubic metres for its own needs, which is the most it can do without interfering with navigation. Eight of these reservoirs will be in the Morvan, on the affluents of the Cure and the Chalaux. The two reservoirs upon which work is now in progress are the Chaumeçon and the Crescent, at the junction of the Chalaux and the Cure. Their total area will be 800 acres. From the Crescent lake a tunnel is being driven through the rock to a point where there is a fall of 100 m. in the valley of the Cure, and where a power station will be built. The capacity of the reservoirs now under construction will be about 33½ million cubic metres. It is expected that the Crescent lake will be ready to be filled towards the end of next year.

Railway Disasters.

Recent railway accidents, due to the sagging of the permanent way as the result of heavy rains, were attributed in the Chamber of Deputies to the unsuitable character of the ballast. This criticism was not convincing, but it was admitted that the danger of derailments would be reduced by a more thorough inspection of the permanent way. The companies already do what they can, and it was suggested that, in view of the expense involved, the State should itself organise an independent inspection service. The Orleans Railway Company appears to have taken ordinary precautions against the accident which occurred in the early hours of Saturday morning last to the express between Paris and Nantes, when the locomotive left the rails and fell into the Loire, the coaches being piled up and smashed, though, fortunately without loss of life, except to the driver of the locomotive. At that point the line follows the bank of the Loire, with, on the other side, an incline where there were indications of a possible fall of rock loosened by the rains. A man was stationed there to give warning in case there should be signs of danger, but he was engulfed in a mass of rock and mud that suddenly rolled down the incline on to the track. Immediately afterwards the train reached the spot at a speed of close upon 60 miles an hour. The locomotive turned over into the swollen Loire. Many passengers were more or less seriously injured in the smashed coaches, and the guard, though half scalped, succeeded in reaching the nearest station to give the alarm.

Motor Coaches.

The State Railways have for years past been experimenting with different types of motor coaches on lines with small traffic. They have ordered ten such vehicles weighing 9½ tons and fitted with 110 horse-power petrol engines, which, however, will be replaced eventually by heavy oil engines. Three of these coaches are being run on the Caen–Laval line. Others will probably be put in service between Poitiers and La Rochelle.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

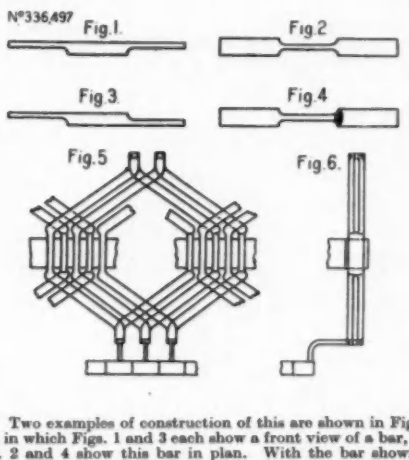
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS.

336,497. December 10th, 1929.—SINGLE LAYER WINDINGS OF COMMUTATOR MACHINES, Siemens-Schuckertwerke Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

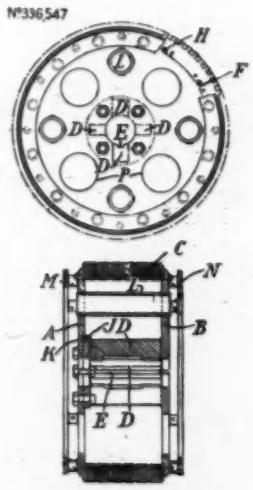
In many cases, as, for example, in the production of single layer windings, the making of the winding presents great difficulties, in so far as there is insufficient room for the surfaces of the windings. This disadvantage is overcome, according to this invention, by the end portions of the bars, from which the windings are made being reduced in the direction of the height of the bar as compared with the part of the bar lying in the groove, and being increased in the direction of the width of the



bar. Two examples of construction of this are shown in Figs. 1 to 4, in which Figs. 1 and 3 each show a front view of a bar, and Figs. 2 and 4 show this bar in plan. With the bar shown in Figs. 1 and 2 the two end portions are on the same side of the narrowed part of the slot portion of the bar, while with the bar shown in Figs. 3 and 4 the end portions are on opposite sides of the narrow part of the groove portion of the bar. The first form of construction is used with advantage for single commutator machines and the second for double commutator machines. In Figs. 5 and 6 a winding of bars formed according to the invention is shown in elevation and in development.—*October 16th*, 1930.

336,547. March 25th, 1930.—ROTORS FOR DYNAMO-ELECTRIC MACHINES, *Associated Electrical Industries, Ltd., of Bush House, Aldwych, in the City of Westminster.*

The object of this invention is to provide a fabricated rotor wherein welded joints between the shaft and the laminated rim are avoided. Two circular plates A and B support a laminated core structure C. The plates are held spaced in an axial direction by longitudinal spacing members or hub blocks D. One of the pieces has a groove or keyway E in alignment with similar grooves in the respective plates. A key member fastens the combined structure to the shaft. The laminated core structure comprises laminations having recesses F for supporting the structure. The recesses are of generally circular form, but one side is cut away. By virtue of the cut away portion of the circular recesses, it is possible to assemble the individual laminations on threaded assembly rods H without the necessity of sliding each

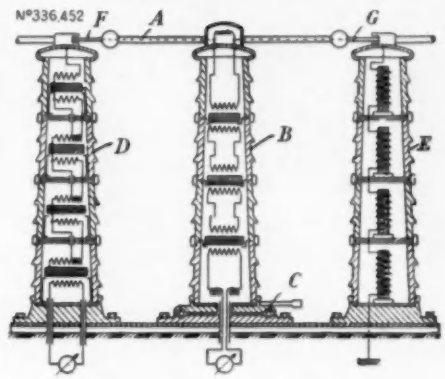


lamination along the rod until it reaches its proper place as an element of the core. The laminations are held in face to face relation by the annular plates, which are clamped against the core structure by means of tightening nuts on the rods H, and these plates also serve to transmit torque from the core rim to the shaft or *vice versâ*. For convenience in assembling, a centring plate J is provided, which engages a corresponding recess K in the inner face of the end plate A and is welded to corresponding ends of the longitudinal spacing members D on the opposite ends of which is welded the plate B. In order to ensure additional rigidity to the structure, pipes L may be passed through holes in the plates A and B and spot welded thereto as indicated. The plates A and B may carry rings M and N spaced therefrom for supporting the end turns of the coil. The tightening plates A and B may also have holes P in order to lighten the structure and facilitate cooling.—*October 16th*, 1930.

SWITCHGEAR.

336,452. October 31st, 1929.—HIGH-POTENTIAL AIR-BREAK ELECTRIC SWITCHES, Koch and Sterzel A.G., of Zwickauer Strasse 40/42, Dresden, A. 24, Germany.

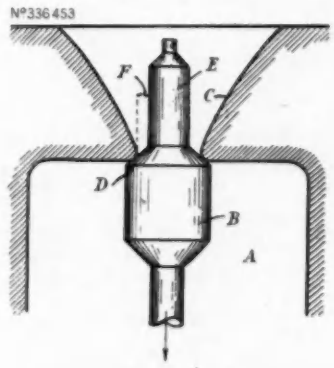
This invention relates to extra high-tension air break electric switches for use in conjunction with overhead conductor systems, in which the switch parts are carried on separate insulators constructed of built-up sections. The drawing illustrates the application of the invention to a double-arm rotary switch, in which the switch blade A is fixed at its mid point to the upper end of an insulator B mounted on a ball race C and situated between two fixed insulators D E. By constructing the third insulator B as the insulator housing of a measuring transformer, both connections of the current transformer with the line conductors are interrupted when the switch blade A is opened. In the case of a knife blade or single-arm rotary switch, connection of one of the conductors with the knife blade is maintained. With a



double-arm rotary switch constructed according to the invention, the advantage is obtained that the measuring transformer within the centre insulator may, in the case of a fault occurring, be cut out entirely, and be inspected or exchanged without danger. If a current-measuring transformer is provided within the rotatable insulator, then one arm F of the switch blade forms one connection, and the other arm G the other connection for the current transformer. The centre insulator may, of course, be fixed and the double-arm switch blade be moved by itself, as can also be the case with a single-arm pivoted switch blade arranged on one of two fixed insulators. When, in a rotary switch with three insulators, B D E, one insulator B is arranged to contain a current transformer and another D a potential transformer, as shown, then the third insulator E permits of the fitting of a graduated choking or earthed choking coil.—*October 16th*, 1930.

336,453. November 1st, 1929.—HIGH-TENSION ELECTRIC SWITCHES, *International General Electric Company, Inc., of 120, Broadway, New York.*

The breaking operation of the switch described in this specification is divided into three stages. In the first stage the contacts are separated as swiftly as possible to a distance apart which cannot be jumped by the operating voltage. The sequence of the three stages may be obtained by suitably designing the switch-operating mechanism used for moving the contacts quickly, slowly, and quickly in succession. It is, however, preferable to vary the active gap between the contacts by moving the latter uniformly and by shaping them as shown in the accompanying drawing. Compressed gas flows out of the enclosed

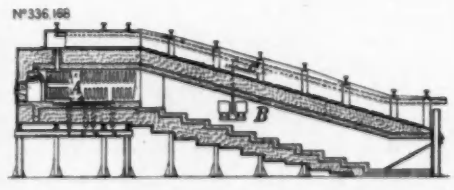


space A. In the position illustrated, the movable contact B closes the outlet aperture provided on the stationary contact C. The contact B comprises a stout portion carrying the contact faces D proper, and a smaller cylinder E adjacent to the stout portion. When moving the contact B in the direction of the arrow, an arc is formed between the faces previously in contact, this arc being very rapidly transferred to the cylinder E by the action of the outrushing compressed gas. The arc gap between the electrodes is now equal to the radial gap F between the stationary contact and this cylinder. This gap does not vary while the contact moves through a distance equal to the length of the cylinder E. The active gap between the contacts increases only when this cylinder has moved clear of the stationary contact.—*November 1st*, 1930.

FURNACES.

336,168. December 18th, 1929.—ELECTRIC FURNACES, *The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C. 2.*

This invention concerns an electrically heated furnace for



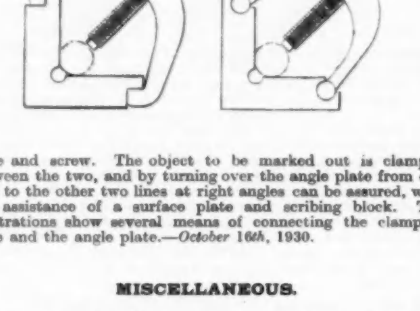
the baking of vitreous enamel ware, and aims at conserving heat as much as is possible. The actual oven, with its heating elements, is shown at A. It is preceded by a regenerative

chamber B, through which the articles to be baked are carried by a travelling conveyor. This conveyor goes up one side of the chamber, round a hairpin bend in the oven and down the other side of the chamber. In this way heat radiating from the out-going articles is used to warm up the new charge. It is suggested that while the charge may go into the furnace at 25 deg. Cent., it will be heated to 675 deg. before it arrives in the oven, and that, leaving the oven at 865 deg., it will be reduced to 130 deg. at the exit from the regenerative chamber.—*October 9th*, 1930.

MACHINE TOOLS AND SHOP APPLIANCES.

336,474. November 18th, 1928.—Machine Cramps, E. J. Lane, Kilnwood, Richmond-road, Kingston, Surrey.

This device is evidently intended for "squaring off" to get the centre of a circle in marking out jobs and similar work. It comprises a right-angled plate in combination with a clamping

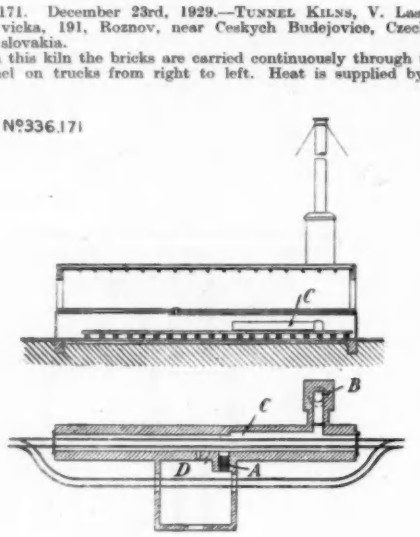


yoke and screw. The object to be marked out is clamped between the two, and by turning over the angle plate from one face to the other two lines at right angles can be assured, with the assistance of a surface plate and scribing block. The illustrations show several means of connecting the clamping yoke and the angle plate.—*October 16th*, 1930.

MISCELLANEOUS.

336,171. December 23rd, 1929.—Tunnel Kilns, V. Lastovicka, 191, Roznov, near Ceskych Budejovice, Czechoslovakia.

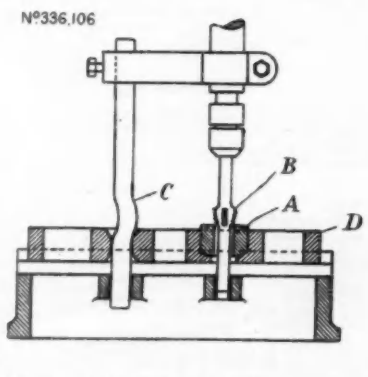
In this kiln the bricks are carried continuously through the tunnel on trucks from right to left. Heat is supplied by a



furnace at A. The chimney is at B. There is a recess C in the wall of the tunnel above the level of the truck platforms to induce the hot gases to pass between and over the bricks, while cold air is admitted below at D to cool the trucks. The out-going charge is cooled by the admission of air beneath the door on the left.—*October 9th*, 1930.

336,106. October 16th, 1929.—Lock Nuts, E. Helin, 24, Narvägeten, Stockholm, Sweden.

This is a machine for producing self-locking nuts of the kind that depend upon distortion of the thread. The nut A is



threaded by means of the tap B, while the nut itself is "joggled" round by the cramped arm C and the jig D. The result is a threaded bore in the nut larger at the centre than at either extremity.—*October 9th*, 1930.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

Institution of Electrical Engineers: North-Eastern Students' Section.—Armstrong College, Newcastle-on-Tyne. "Insulation Testing." 7.15 p.m.

Institution of Mechanical Engineers.—Storey's-gate, St. James's Park, London, S.W. 1. Informal meeting. Discussion on "Export Trade Emancipation," introduced by Mr. Edward Batten. 7 p.m.

Institution of Municipal and County Engineers.—Scottish District meeting at County Buildings, Paisley. Address by Mr. Thomas Somers on the Sixth International Road Congress at Washington, D.C. 2 p.m.

Junior Institution of Engineers.—39, Victoria-street, S.W. 1. "Photography Applied to Science," by Mr. G. H. Willett. 7.30 p.m.

Keighley Association of Engineers.—Queen's Hotel, Keighley. Ladies' night. 7.30 p.m.

Manchester Association of Engineers.—The Engineers' Club, 17, Albert-square, Manchester. "The Selection and Treatment of Materials for Gears," by Mr. F. W. Rowe. 7.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—In the Lecture Theatre of the Mining Institute, Newcastle-upon-Tyne. "The Ocean-going Tramp Steamer from the Owner's Point of View," by Mr. W. Stanley Hinde. 6 p.m.

SATURDAY, NOVEMBER 29TH.

Co-ordinating Committee Representing Staffordshire Iron and Steel Institute, Birmingham Metallurgical Society (Inc.), Birmingham Local Section of the Institute of Metals.—In the Queen's Hotel, Birmingham. Reception, 6.30 to 7 p.m.; dinner, 7 p.m.

MONDAY, DECEMBER 1ST.

Bradford Engineering Society.—Bradford Technical College. "The Application of Diesel Engines to Road Transport," by Mr. W. H. Goddard. 7.30 p.m.

Railway Club.—57, Fetter-lane, E.C. 4. "The Coats of Arms of the Principal British Railways Pre-grouping," by Mr. G. W. J. Potter. 7.30 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. Cantor Lecture, "Modern Domestic Scientific Appliances, Lecture II.," by Professor C. R Darling. 8 p.m.

Society of Chemical Industry: London Section.—In the Rooms of the Chemical Society, Burlington House, W. 1. "Analytical Chemistry, its Past History and Future Development," by Mr. J. H. Coste. 8 p.m.

Society of Engineers.—In the Apartments of the Geological Society, Burlington House, W. (entrance at the east end of the building in Piccadilly). "Some Ground Aspects of Aviation," by Mr. W. R. Baldwin-Wiseman. 6 p.m.

Wolverhampton and District Engineering Society.—Victoria Hotel, Wolverhampton. "The Machine Tool in Relation to Modern Engineering Practice," by Mr. H. A. Drane. 7.30 p.m.

TUESDAY, DECEMBER 2ND.

Institute of Metals: Scottish Local Section.—Joint meeting with the Institution of Engineers and Shipbuilders in Scotland. 39, Elmbank-crescent, Glasgow. "Non-ferrous Alloys Used by Engineers," by Mr. Wesley Lambert. 7.30 p.m.

Institution of Automobile Engineers.—Royal Society of Arts, John-street, Adelphi, W.C. 2. "Some Experiments on the Factors Affecting the Motion of a Four-wheeled Vehicle when some of its Wheels are Locked," by Mr. J. Bradley and Mr. S. A. Wood; "Factors Affecting the Behaviour of Rubber-tired Wheels on Road Surfaces," by Mr. J. Bradley and Mr. R. F. Allen. 7.45 p.m.

Institution of Civil Engineers.—Great George-street, S.W. 1. "Cairo Main Drainage Extensions," by Mr. A. O. W. D. Pinson. 6 p.m.

WEDNESDAY, DECEMBER 3RD.

Business Research and Management Association of Great Britain.—Anderton's Hotel, Fleet-street, London, E.C. 4. "Budgetary Control in a Small Business," by Mr. A. Parker. 6.45 p.m.

Institution of Heating and Ventilating Engineers.—Swedenborg Hall, 20, Hart-street, Bloomsbury, W.C. 1 (entrance in Barter-street). "The Cost of Operating Industrial and Private Electric Generating Sets Compared with Public Supply," by Mr. E. G. Phillips. 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—Bolbec Hall, Newcastle-upon-Tyne. Graduate Section. "Wharf Cranes for the Handling of Cargo," by Mr. J. C. Dixon. 7.15 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. "The Building of the Mansion House," by Mr. Sydney Perks. 8 p.m.

THURSDAY, DECEMBER 4TH.

British Association of Refrigeration.—The Hall of the Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W. 1. "Latest Achievements in Rapid Freezing and Chilling," by Mr. M. T. Zarotschenzeff. Discussion. 5.30 p.m.

Institution of Civil Engineers: Birmingham and District Association.—At the Queen's Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Institution of Electrical Engineers.—In the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "Loud-speakers since their Conception with Gramophone Pick-ups and Wireless Recording Apparatus" (with demonstrations), by Mr. S. G. Brown, F.R.S. 6 p.m.

Institution of Mechanical Engineers: North-Western Branch.—Engineers' Club, Albert-square, Manchester. Annual dinner. 6.30 for 7 p.m.

THURSDAY AND FRIDAY, DECEMBER 4TH AND 5TH.

Institution of Chemical Engineers.—In the Rooms of the Chemical Society, Burlington House, Piccadilly, W. 1. Conference on "The Utilisation of Trade Wastes." Thursday.—Papers: "Industrial Wastes," by Mr. John B. C. Kershaw; "The Treatment of Suint Liquors from Wool Scouring," by Mr. A. T. King; "The Treatment and Disposal of Wool Washing Effluent," by Mr. Basil A. Smith. Discussion. 10.30 a.m. Papers: "Whitewater in Paper and Pulp Mills and its Utilisation," by Mr. Robert J. Marx; "The Distillation of Wood Waste and the Utilisation of the Products," by Mr. M. Schofield; "The Utilisation of Industrial By-products, with Special Reference to the Pulp Industry of the United States of America," by Mr. Robert W. Griffith. 2.30 p.m. Friday.—Papers: "The Problem of Tannery Waste," by Mr. D. Jordan Lloyd; "The Use of Wood Waste for Heating and Generation of Power," by Mr. Oswald Wans. Discussion. 10.30 a.m. Papers: "The Utilisation of Waste Rubber," by Mr. E. B. Busenburg; "The Recovery of Metal from Waste Materials," by Mr. J. W. Hinchley. Discussion. 2.30 p.m.

FRIDAY, DECEMBER 5TH.

Institution of Mechanical Engineers.—Storey's-gate, St. James's Park, London, S.W. 1. Extra general meeting. "Machinery and Methods of Manufacture of Sheet Glass," by Professor W. E. S. Turner. 6 p.m.

Junior Institution of Engineers.—39, Victoria-street, S.W. 1. Informal meeting. "Oil Burning for Domestic Central Heating," by Mr. R. L. Mayston. Slides. 7.30 p.m.

SATURDAY, DECEMBER 6TH.

Institute of British Foundrymen: Lancashire Branch.—At the College of Technology, Sackville-street, Manchester. "Foundries—and Foundries," by Mr. S. H. Russell. 4 p.m.

MONDAY, DECEMBER 8TH.

Imperial College of Science and Technology.—Goldsmiths' Hall, London, E.C. 2. Imperial College dinner. 7 p.m. for 7.30 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. Cantor Lecture, "Modern Domestic Scientific Appliances, Lecture III.," by Professor C. R. Darling. 8 p.m.

MONDAY TO FRIDAY, DECEMBER 8TH TO 12TH.

Smithfield Club Show, 1930.—Agricultural Hall, Islington, N. Annual Show. 9 a.m. to 9 p.m. daily.

TUESDAY, DECEMBER 9TH.

Institute of British Foundrymen: Lancashire Branch, Burnley Section.—At the Municipal Technical College, Ormerod-road, Burnley. "Survey in Making of Light Castings," by Mr. F. Harris. 7.15 p.m.

Institute of Metals: North-East Coast Local Section.—In the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. "Properties of Coke," by Professor H. V. A. Briscoe. 7.30 p.m.

Institute of Metals: Swansea Local Section.—At University College, Singleton Park, Swansea. Lecture and demonstration on "Copper Welding," by Messrs. W. Andrews and H. Martin. 6.15 p.m.

THURSDAY, DECEMBER 11TH.

Institute of Metals: Birmingham Local Section.—In the Chamber of Commerce, New-street, Birmingham. "Plating," by Mr. E. J. Dobbs. 7 p.m.

Institute of Metals: London Local Section.—Joint meeting with the London Branch of the Institute of British Foundrymen, in the Meeting Room of the Chemical Society, Burlington House, W. 1. "Magnesium Alloy Castings," by Mr. E. Player. 8 p.m.

Institution of Welding Engineers.—The Institution of Mechanical Engineers, Storey's-gate, St. James's Park, London, S.W. 1. "The Fabrication of Plant in Acid-resisting Steels," by Mr. C. C. Hall. The paper will be illustrated by a film and lantern slides and will be followed by a discussion. 7.45 p.m.

Royal Aeronautical Society.—16, John-street, Adelphi, W.C. 2. "The Origin and Development of Heavy Oil Aero-engines," by Mr. D. R. Pye. 6.30 p.m.

FRIDAY, DECEMBER 12TH.

Institute of Metals: Sheffield Local Section.—In the Non-ferrous Section of the Applied Science Department, the University, St. George's-square, Sheffield. "Studies in the Electro-deposition of Silver: Throwing Power: The Behaviour of Silver Anodes, with Special Reference to Blackening and its Prevention," by Mr. R. N. D. Barklie and Mr. A. E. Nicol. 7.30 p.m.

Junior Institution of Engineers.—At the Royal Society of Arts, John-street, Adelphi, W.C. 2. Presentation of awards by Sir Ernest Moir and induction of new President, Colonel Sir Henry George Lyons, F.R.S. Presidential address, "Technical Museums and their Value to Engineers." 7.30 p.m.

TUESDAY, DECEMBER 16TH.

Institution of Mechanical Engineers: Yorkshire Branch.—Alteration of programme, preliminary announcement. In order to facilitate the visit of the President to the Branch, it has been arranged that the date of the Chairman's address at Leeds be brought forward from Thursday, December 18th, to Tuesday, December 16th.

WEDNESDAY, DECEMBER 17TH.

Institution of Locomotive Engineers (London).—Denison House, 296, Vauxhall Bridge-road, Westminster, S.W. 1. "Possibilities of Condensing on Locomotives," by Mr. H. I. Andrews. 6 p.m.

FRIDAY, DECEMBER 19TH.

Junior Institution of Engineers.—39, Victoria-street, S.W. 1. Informal meeting. "Well Drill Blasting," by Mr. W. Cullen. 7.30 p.m.

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SATURDAY, JANUARY 10TH, 1931.

Institute of British Foundrymen: Lancashire Branch.—At the Grand Hotel, Manchester. Annual dinner. 6.30 p.m.

WEDNESDAY, MARCH 25TH, 1931.

Association of Special Libraries and Information Bureaux.—At the Institution of Mechanical Engineers, Storey's-gate, London, S.W. 1. "George Stephenson's Institute and its Library." 7 p.m.

National Institute of Industrial Psychology.—The National Institute of Industrial Psychology celebrates its tenth birthday next year, and Dr. C. S. Myers, who has been director of the Institute since its inception, has asked to be released from the duties of directorship on being appointed Principal in order that he may devote the whole of his time to the Institute's research and educational activities. Dr. G. H. Miles, who has been assistant director for several years, has been appointed director of the Institute.

Lantern Slides of Crushing and Conveying Machinery.—British Jeffrey-Diamond Ltd., of Stennard Works, Wakefield, asks us to announce that it has prepared a selection of lantern slides illustrating all the latest developments in material-handling plant, such as coal breakers, swing-hammer pulverisers, a wide range of crushers, portable belt and bucket loaders, trolley conveyors, storage battery and trolley type locomotives, belt conveyors, portable stackers and many other examples of similar equipment. These lantern slides the company is prepared to lend to technical lecturers and teachers for educational purposes.